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Compressed Air Magazine

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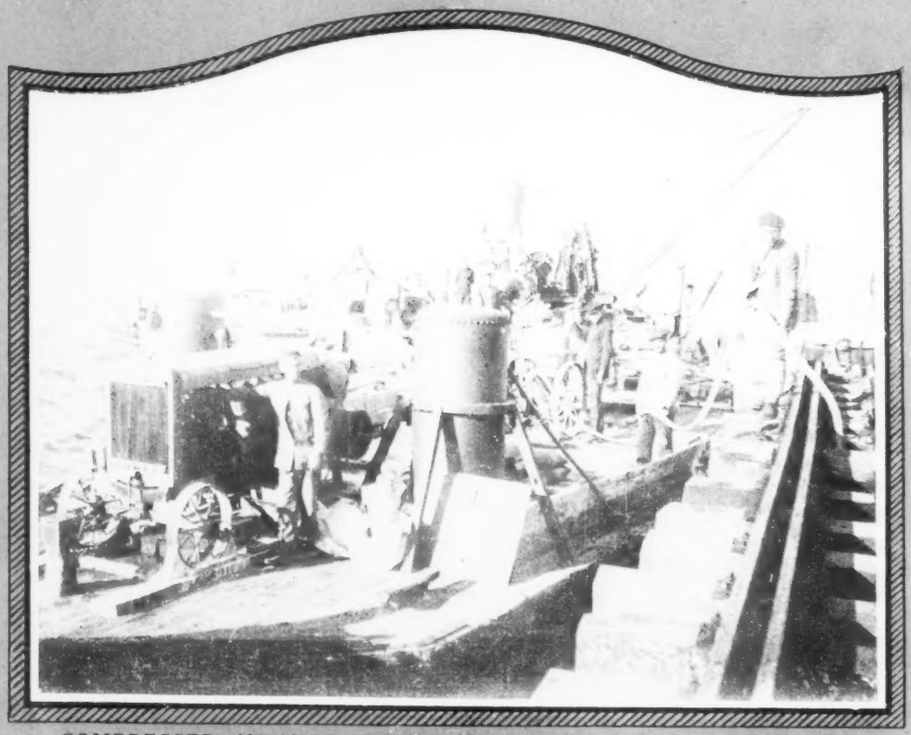


COMPRESSED AIR AIDS IN BINDING A SEA WALL NOW BUILDING IN THE PORT OF ALGECIRAS, SPAIN

Extending New York City's Subways
C. H. Vivian

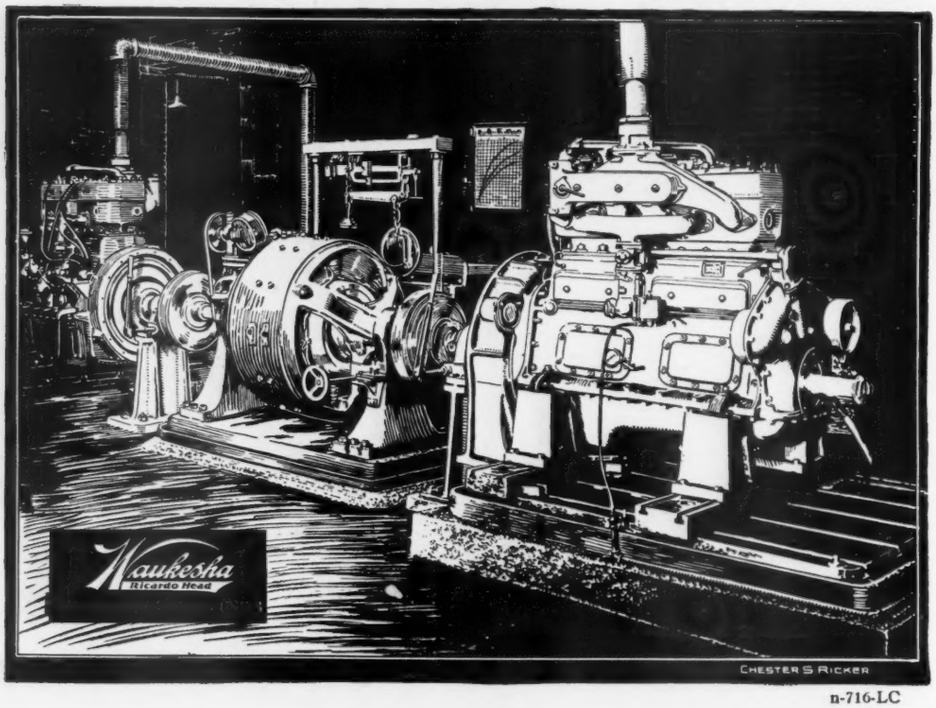
Oil Engine Effects Significant Economies
S. G. Roberts

Conowingo Development Well Underway
R. G. Skerrett

Wonders Worked by Selective Flotation
Gail Martin

(TABLE OF CONTENTS AND ADVERTISERS' INDEX, PAGE 5)

Testing Heavy Duty Waukesha "Ricardo Head" Engines on Electric Dynamometer



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CONTENTS OF THIS ISSUE

Vol. XXXII, No. VI, June, 1927

NOTE—For subscription terms see first Editorial page

Articles

Susquehanna River to Supply Electric Energy to Philadelphia. *R. G. Skerrett* 2033

Calyx Drill Minimizes Famine Menace. *Sidney Mornington* 2041

Compressed Air Keeps Switches Clean 2042

Extending New York City's Subways. *C. H. Vivian* 2043

Compressed Air Serves to Drain Crankcases..... 2050

Air-Operated Gates at Grade Crossings 2050

Modern Drilling Equipment in Quarry Greatly Increases Output. *S. G. Roberts* 2051

Pan-American Railway Nearer Realization 2052

Basic Facts About Bricks 2052

Electricity Helping the Farmer 2052

Oil Engine Effects Significant Economies. *A. S. Taylor* 2053

Concrete Raised to Exceptional Height by Compressed Air. *Allen Park* 2057

Fighting the Corn Borer with Fire 2058

Wonders Worked by Selective Flotation. *Gail Martin* 2059

Preheaters Useful in Track Maintenance 2063

Notes of Industry 2064

Editorials—Mississippi Takes Toll for Man's Intrusion—Another Alpine Tunnel is Proposed—Much Longer Power Lines a Probability—From Africa to Venus 2066

Announcement 2066

Book Reviews 2066

Advertisements

Annis, Emmett F. 29
Audel & Co., Theo. 29
Bucyrus Company 22
Bury Compressor Co. 14
Cameron, A. S., Steam Pump Works 24
Continental Motors Corp. 23
Direct Separator Co. 31
Erie Steam Shovel Co. 28
France Packing Co. 30
Garlock Packing Co., The 5
General Electric Co. 16
Goodrich, B. F. 15
Goodyear Tire & Rubber Co. 18
Hercules Powder Co. 10-11
Ingersoll-Rand Co. 6-7-33
Jarecki Mfg. Co. 30
Jenkins Bros. 26
Jewett 26
Ladew Co., Inc., Edw. R. 31
Linde Air Products Co. 25
Manzel Bros. Co. 28
Maxim Silencer Co. 3
Midwest Air Filter Co. 29
New Jersey Meter Co. 30
Nordberg Mfg. Co. 8
Oxweld Acetylene Co. 4
Prest-O-Lite Co. 19
Smith-Monroe Co. 31
Staynew Filter Co., Inc. 12-13
Stowe, George M., Jr. 26
Swartwout Company 28
Union Carbide Sales Company 21
Vacuum Oil Co. ..... Back Cover
Victaulic Co. of America 28
Waukesha Motor Co. 2
Western Wheeled Scraper Co. 9
Westinghouse Elec. & Mfg. Co. 27

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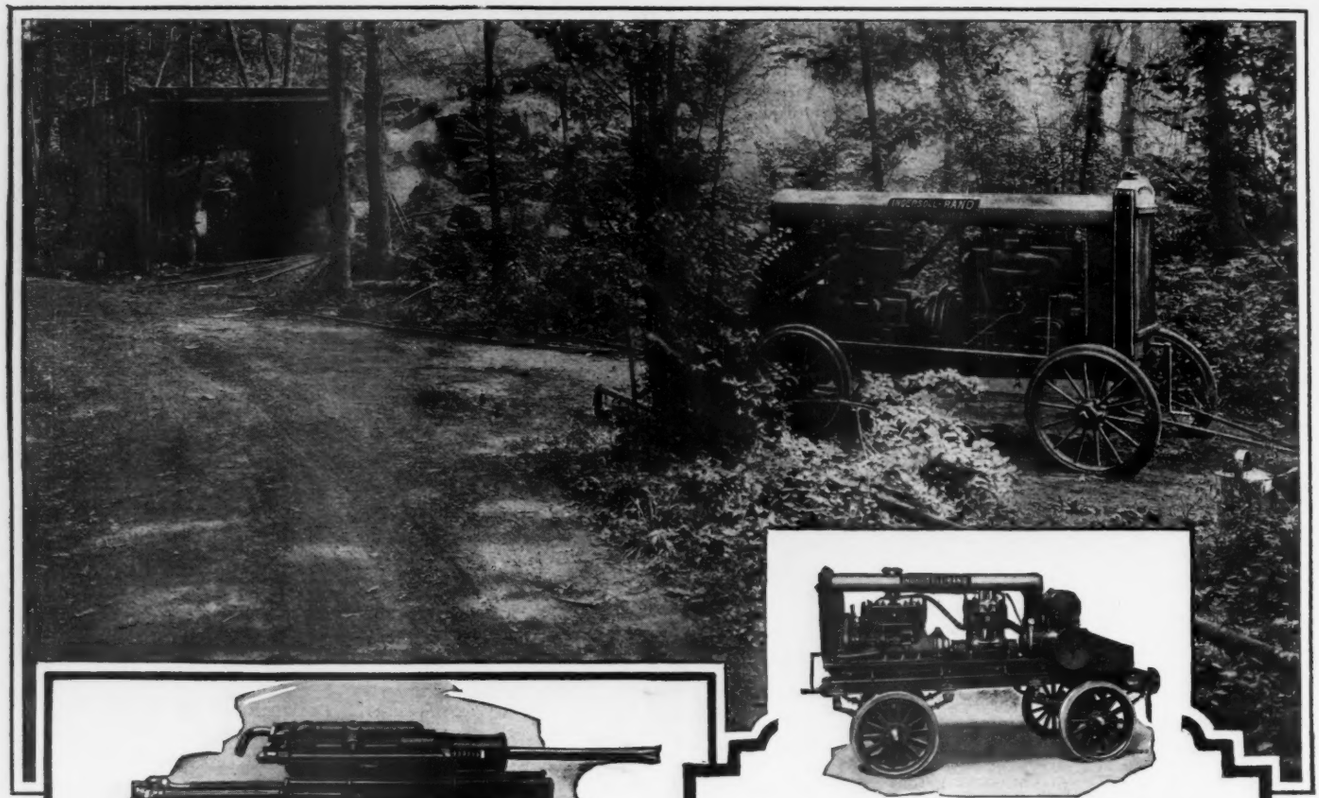

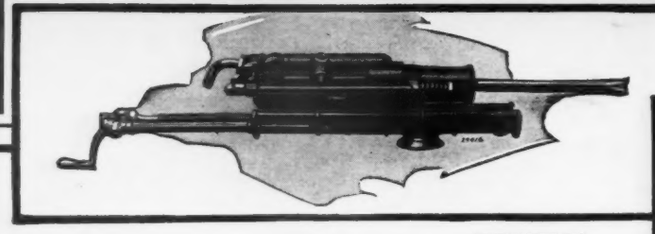

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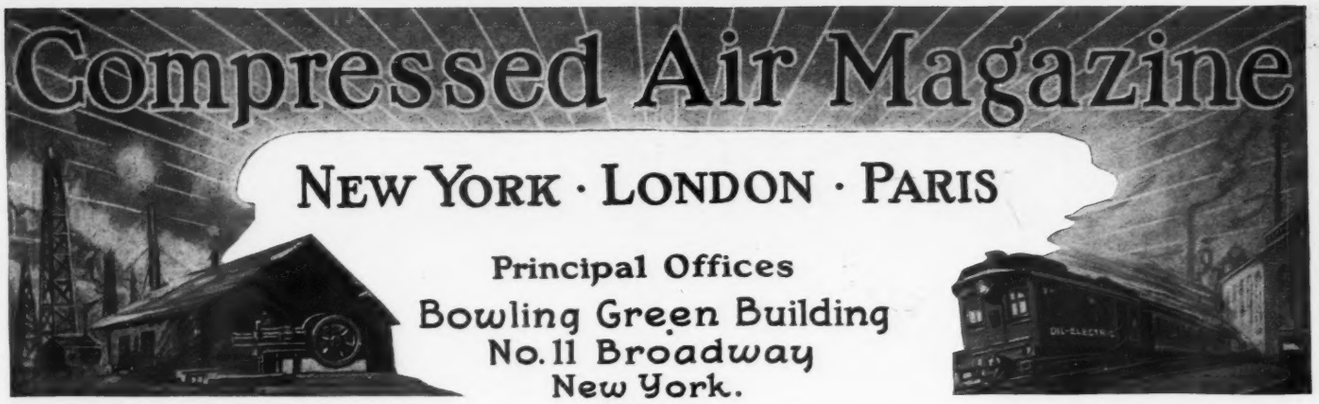

VOL. XXXII, NO. VI

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JUNE, 1927

Susquehanna River To Supply Electric Energy To Philadelphia

Great Dam and Powerhouse Building Near Conowingo, Maryland, To Develop Nearly 600,000 Horsepower

By ROBERT G. SKERRETT

CONOWINGO will be a name to conjure with a year hence when the great hydro-electric plant now building near there on the Susquehanna is completed. At the start, the plant will develop 378,000 H.P. of electric energy, and this output will ultimately be increased to 594,000 H.P. when the last of the projected generators is installed.

The nature of the setting for the dam and the powerhouse, the magnitude of the undertaking, and the fact that the current produced will be transmitted to Philadelphia, 70 miles away, all add to the interest that this scheme has aroused among engineers. It has been computed that this use of the flow of the Susquehanna River will lead to a fuel saving amounting substantially to 750,000 tons of coal annually.

For untold ages, what we now call the Susquehanna River has been draining an enormous watershed; and within the period during which that stream has been making its way seaward it has cut for itself a deep path through the underlying rock. Also, by reason of this erosive action, the waters have formed a valley, with steep slopes, that lends itself, especially in the lower part of the river, to the erection of dams wherewith to create extensive pools for the driving of waterwheels.

Despite the fact that the Susquehanna has long traced its course through a populous section of the United States, still it was not until the last few decades that anything worthy of mention was done to make use of the river for power purposes. About 40 years ago, the Susquehanna Water Power & Paper Company, of Hartford County, Maryland, constructed a small wing dam on the bed of the river to divert some of the flow to a power plant of modest capacity built near by. That plant is of interest now only because it was the first effort to utilize the latent energy in the Susquehanna; and the service of that plant was a strictly local one.

FOR fifteen years Baltimore has been drawing a very large block of energy from the splendid hydro-electric station built at Holtwood, Pa., on the Susquehanna River. Now, Philadelphia is to obtain, in her turn, a still larger block of energy from the same river through the agencies of a magnificent dam and powerhouse in course of construction near Conowingo, in Maryland.

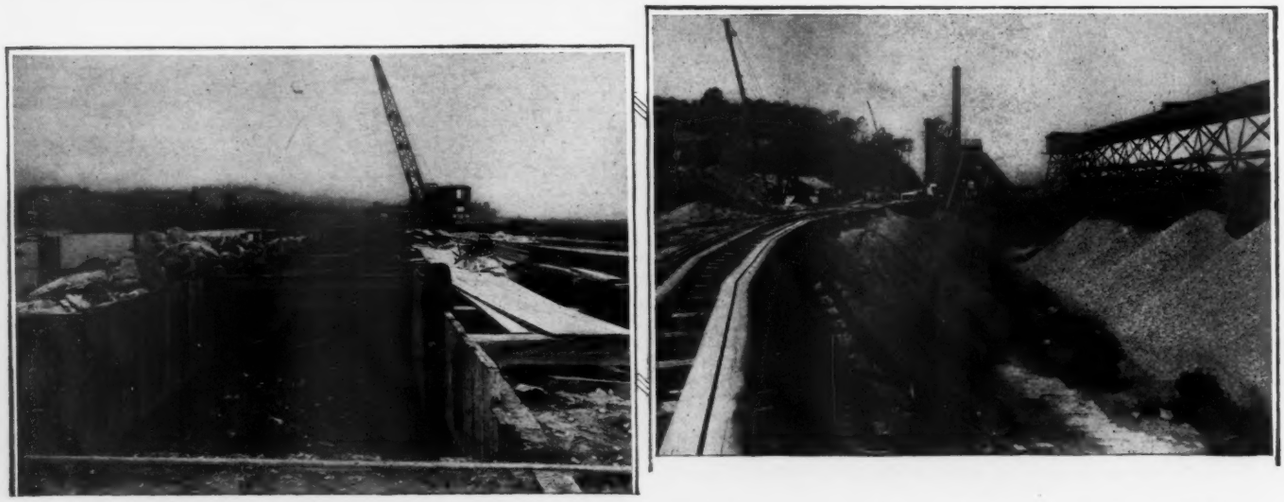
In each case, the plan to utilize the flow of the Susquehanna was not matured until there was developed an available market for so much power within economical transmission distance, and not until the cost of fuel made this use of the river's energy desirable.

The engineering world has every reason to be interested in what The Philadelphia Electric Company is doing at Conowingo. That plant, when completed, will have a capacity of nearly 600,000 H.P., and represent a coal saving of fully 750,000 tons annually.

Fifteen years ago, the Pennsylvania Water & Power Company completed a dam and powerhouse near McCall Ferry, Pa.—that central station now being known as Holtwood. The Holtwood Station has a capacity of 150,000 H.P.; and most of the electric current produced by that big plant is transmitted to Baltimore, where it is utilized in many ways. The Holtwood Station was not constructed until a market had developed for so much electric current within economical distributing distance. Baltimore is about 45 miles away. It is now Philadelphia's demand for more electric current that has brought about the construction of the present undertaking 2 miles below the Village of Conowingo.

Before describing in detail the dam and powerhouse now in course of building, it might be well to touch upon some of the physical characteristics of the Susquehanna that make that river suited for the purposes of the hydro-electric engineer. The basin drained by the Susquehanna embraces a combined area of 27,400 square miles. To be specific, this watershed comprises 47 per cent. of the area of Pennsylvania, 13 per cent. of the area of the State of New York, and 2 per cent. of the area of Maryland. All told, a far-flung and expansive region that has an average annual precipitation of 39.4 inches; and the run-off that reaches the sea by means of the Susquehanna is generally 55 per cent. of the total rainfall during any twelvemonth. The lowest recorded discharge of the river was at the rate of 2,200 cubic feet per second, and the maximum movement during flood stages has amounted to 730,000 cubic feet per second.

While high water occurs most frequently in the first three months of the year because of melting snows and spring rains, still heavy rainfalls at times are apt to induce flood conditions—one of the most notable of these being the flood that swept down the river in June of 1889. These facts indicate that the run-



Left—Cofferdam at east side of the river showing types of fill used to steady and to make the cofferdam watertight. Right—Concrete mixing plant and sand- and stone-storage trestles and conveyors at the west side of the river.

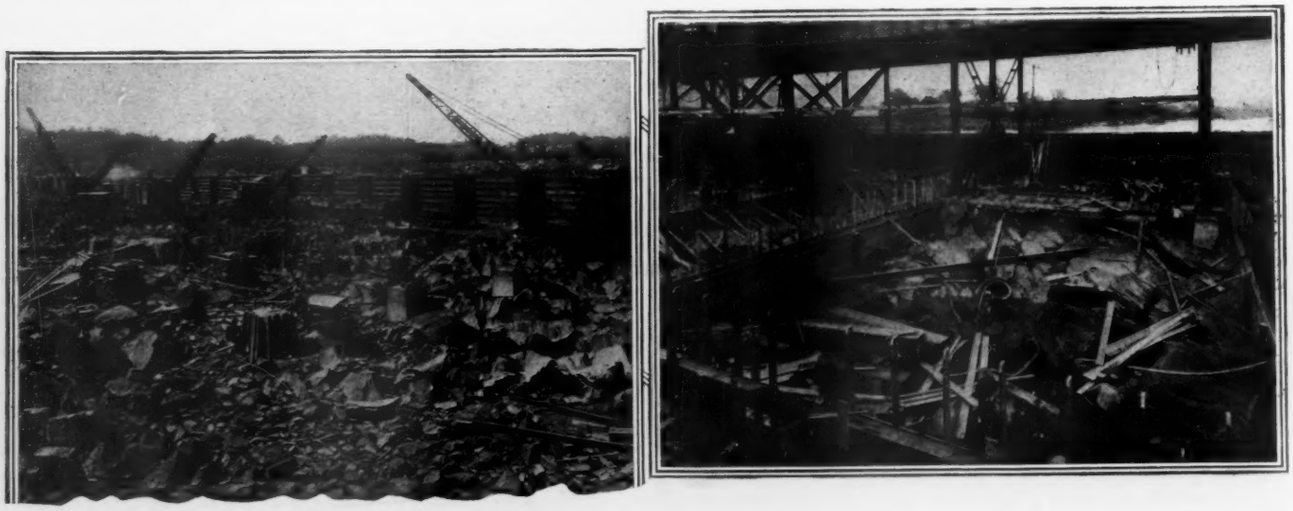
off of the Susquehanna is of a more or less "flashy" nature; and, because of this characteristic, the engineers have had to plan with exceeding care in order properly to control the stream during certain stages of construction work—especially while clearing the dam site and while rearing parts of the dam.

In the last 27 miles of its run, the Susquehanna descends from an elevation of 225 feet and has an average slope of 5.6 feet a mile. This gradient induces a swift current; and it is this current that has worn for itself a channel of great depth in many places. The rock through which the river has cut its way is of granite. This formation will provide a firm foundation for the dam, while the neighboring hillsides will serve as natural abutments to which to anchor the shore ends of the dam. When finished, the spacious basin will extend upstream for a distance of approximately 13 miles. The surface of the pool so created will back up over a portion of the tailrace of the Holtwood Station. The surface of this pool will be at an elevation of 108.5 feet above the mean sea level; and the pool will have a superficial area of fully 14 square miles. The turbines in the Conowingo powerhouse will operate at an average net head of 89 feet.

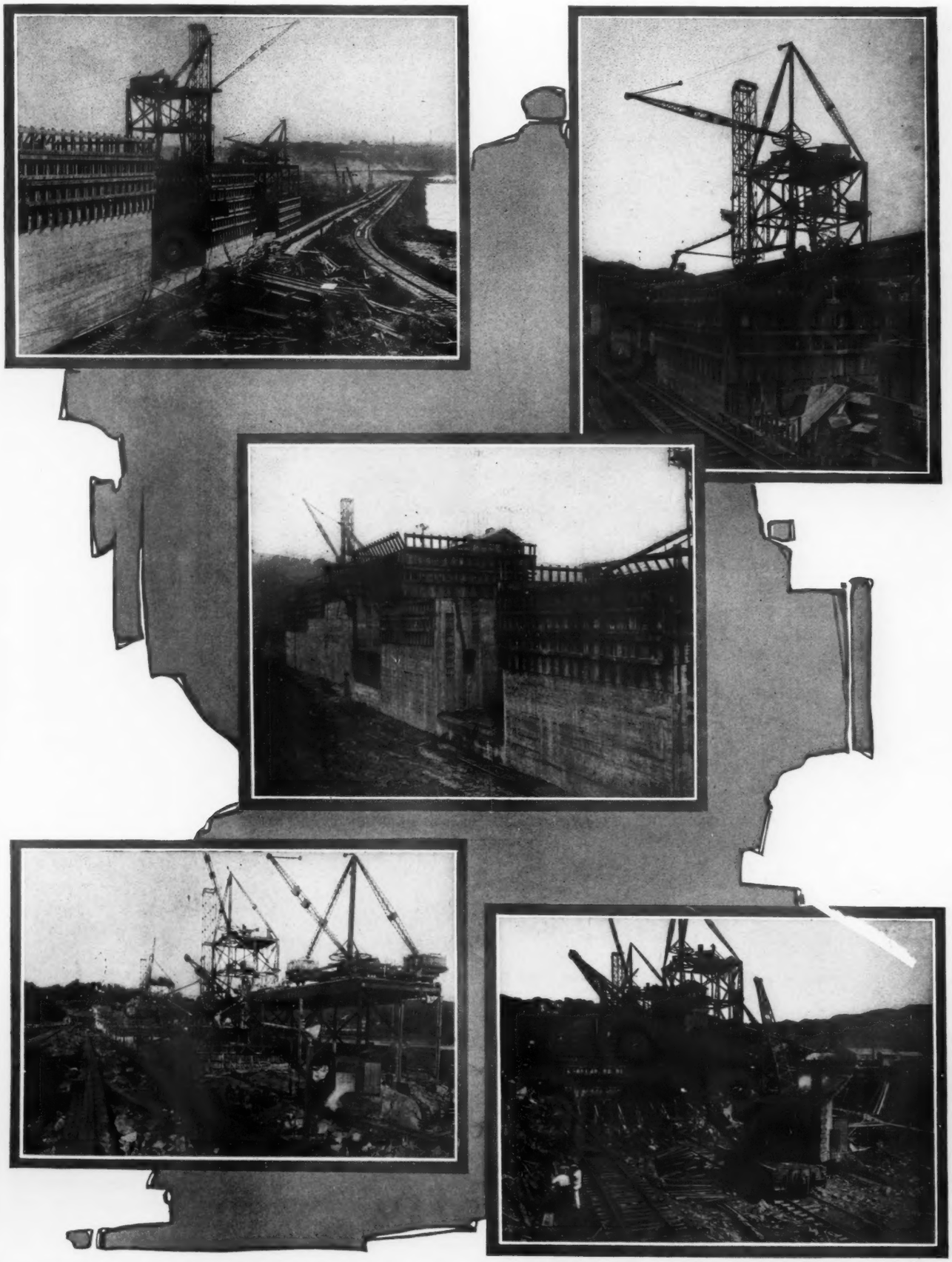
The site of the Conowingo Development was decided upon only after a careful investigation of five sites. For various reasons, the site 2 miles below Conowingo and 4 miles above tidewater was deemed the best one. There the river bed and the flanking banks up to points well above the pool level are of granitic formation. The stability of the rock was ascertained by numerous core borings made along the upstream face of the projected dam—the borings penetrating to depths ranging from 30 to 50 feet below the surface of the ledge. Additional borings carried to a depth of 100 feet revealed sound hard rock throughout their entire length.

Legal restrictions threatened to interfere with the Conowingo Development at the start. To begin with, it was necessary to obtain a license from the Federal Power Commission to erect the dam because the War Department had ruled that the Susquehanna was a navigable river. Next, owing to the fact that the dam and the powerhouse will be in Maryland while the upper half of the reservoir and most of the transmission lines will be in Pennsylvania, joint action was required on the part of the public service commissions of the two states concerned.

From end to end, the dam will have a total length of 4,800 feet, and will be 300 feet longer than the great dam at Muscle Shoals. At its base, the structure will have a maximum spread of 87 feet, and at the spillway section the height will be 86 feet. The spillway, which is 2,385 feet long, is designed so that it will be able to meet flood conditions in which a possible maximum of 880,000 cubic feet of water a second may flow over and through this part of the structure. Upon the spillway will be mounted 50 steel crest gates which can be raised or lowered—the gates moving vertically upon roller trains. These gates will make it practicable to regulate the level of the storage reservoir and to maintain the surface of the pool at an elevation of 108.5 feet. Each of these gates will be 40 feet long and 22½ feet high, and will weigh about 42



Left—Within the downstream cofferdam on the east side of the river, illustrating the work of preparing the river bed along the line of the dam foundation.
Right—This gives a good idea of the manner in which the rock was cleaned preparatory to pouring concrete on it.



Activities at the east end of the dam in connection with the pouring of concrete sections. The open spaces will permit the flow of the river at flood periods while work at the west end of the dam blocks the normal course of the river.

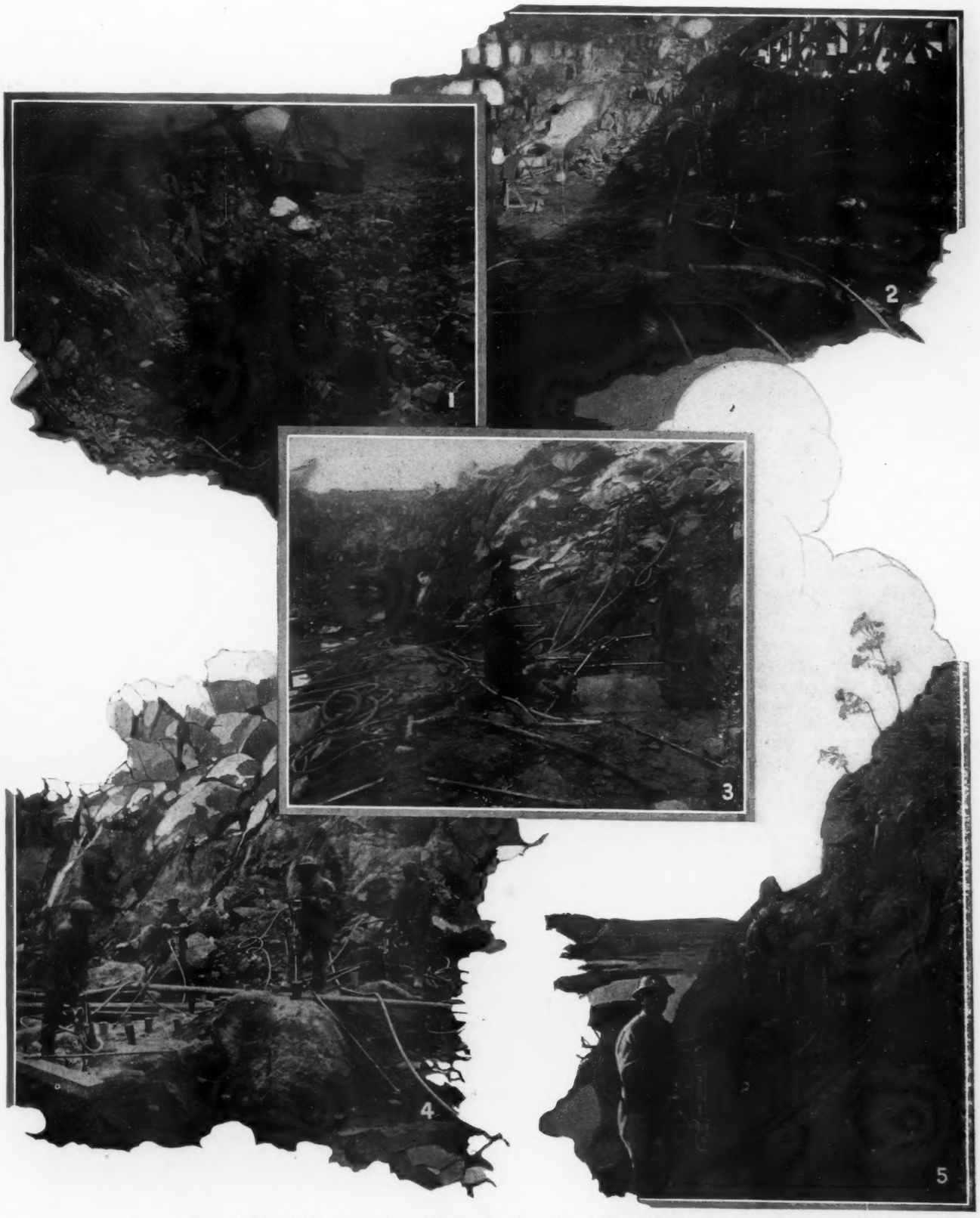
tons. In addition to these gates there will be 3 steel regulating gates, each 10 feet high by 40 feet long, which will be located adjacent to the powerhouse section of the structure. Both the regulating gates and the crest gates will be handled by 3 electrically operated traveling gantry cranes—a runway for this purpose being provided on top of the dam and the powerhouse.

The powerhouse will be incorporated in the dam at its western end, and will be adjacent to the west abutment where the dam is to be keyed into the contiguous rocky hillside. The headworks for the powerhouse will extend eastward for a total length of 900 feet, so that it can accommodate 11 main units. At the start, the powerhouse will be big enough only to hold 7 main units and 2 much smaller station-service units. Each main unit will be driven by a waterwheel capable of developing 54,000 H. P. at full gate, when working at a normal net head of 89 feet, and when making 81.8 revolutions per minute. These waterwheels will be of the vertical-shaft, single-runner, Francis reaction type. Each waterwheel will drive a 40,000 Kv-a. generator. Four of the main waterwheels will be supplied by the Allis Chalmers Manufacturing Company and three by the Wm. Cramp & Sons Ship & Engine Building Company. The two station-service waterwheels will be built by the S. Morgan Smith Company. Each of the latter wheels will develop 1,900 H. P., and drive a generator having a capacity of 1,600 Kv-a. The current dispatched to Philadelphia, after it has been stepped up by transformers, will be of 220,000 volts. The total energy loss between the generators at Conowingo and the distribution buses in Philadelphia will be only 7 per cent.

From the east end of the spillway, the retaining wall section of the dam will extend 1,200 feet to a point where it will terminate in an abutment. This abutment will form part of the highway bridge that will be built over the relocated tracks of the Columbia & Port Deposit Railroad, which runs along the Susquehanna on the east side. The highway bridge on the dam will replace the existing bridge at Conowingo, which will be submerged when the reservoir area is flooded. The relocation of the tracks of the aforementioned branch of the Pennsylvania Railroad calls for the elevation of the existing line so as to be sufficiently above the pool level, and for a gradient of .35 per cent., below the dam, leading to and from the new level. All told, this railroad work will necessitate the changing of the line for 16 miles and the driving of three 2-track tunnels, each of which will be about 300 feet in length. These tunnels are being driven by the bench-and-heading method—the headings being the full width of the tunnels.

All work in connection with the Conowingo Development is being done under the supervision of the Engineering Department of The Philadelphia Electric Company; and the same department will have charge of the operation of the dam and the powerhouse when they are ready for service. The contract for the design and the construction of the dam and the powerhouse was awarded Stone & Webster, Inc., who sublet the building of the greater part of the dam to the Arundel Cor-

1—Compressor plant of Stone & Webster, Incorporated, on the west side of the river. This plant is made up of four XCB-2 machines.
2—A battery of four Ingersoll-Rand portable compressors furnishing air for work in connection with the relocating of the Pennsylvania Railroad.
3—Drill-sharpening shop at the plant of the Arundel Corporation, on the east side of the river.
4—Compressor plant of the Arundel Corporation, on the east side of the river. This plant consists of three XCB-2 compressors.



1—A group of X-71 drills excavating rock at the west side of the dam site.

2—Drilling rock in the excavation at the east abutment with X-71 drifters.

3—Excavating rock at the site of one of the draft tubes with X-71 drills.

4—Blockholing with "Jackhamers" where the draft tubes will be placed beneath the powerhouse.

5—"Jackhamers" drilling rock on hillside along the relocated line of the Pennsylvania Railroad.

Rock made ready at the east end of the dam for the pouring of the concrete sections of that massive structure.

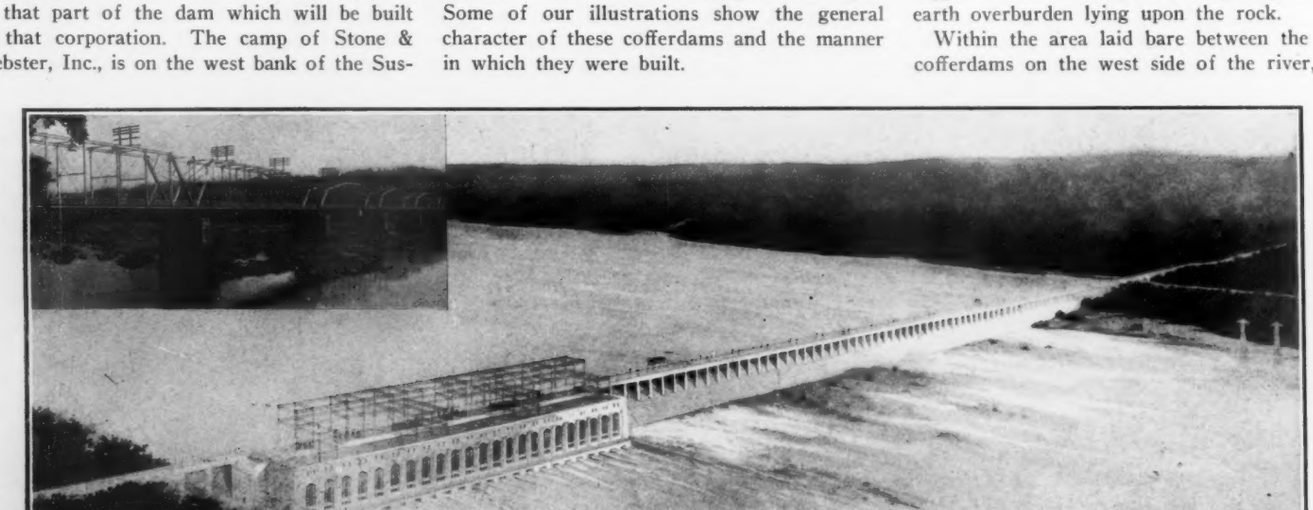
Where the west end of the dam is tied to the face of the rocky hillside.

poration of Baltimore. The Arundel Corporation has also been awarded the contract for relocating the tracks of the Columbia & Port Deposit Branch of the Pennsylvania Railroad. The contract for the design and the construction of the transmission lines and for the switching station, to be located on the roof of the powerhouse, was awarded to Day & Zimmerman, Inc. The Conowingo Development and the connecting transmission lines will entail an estimated outlay of $52,220,000.

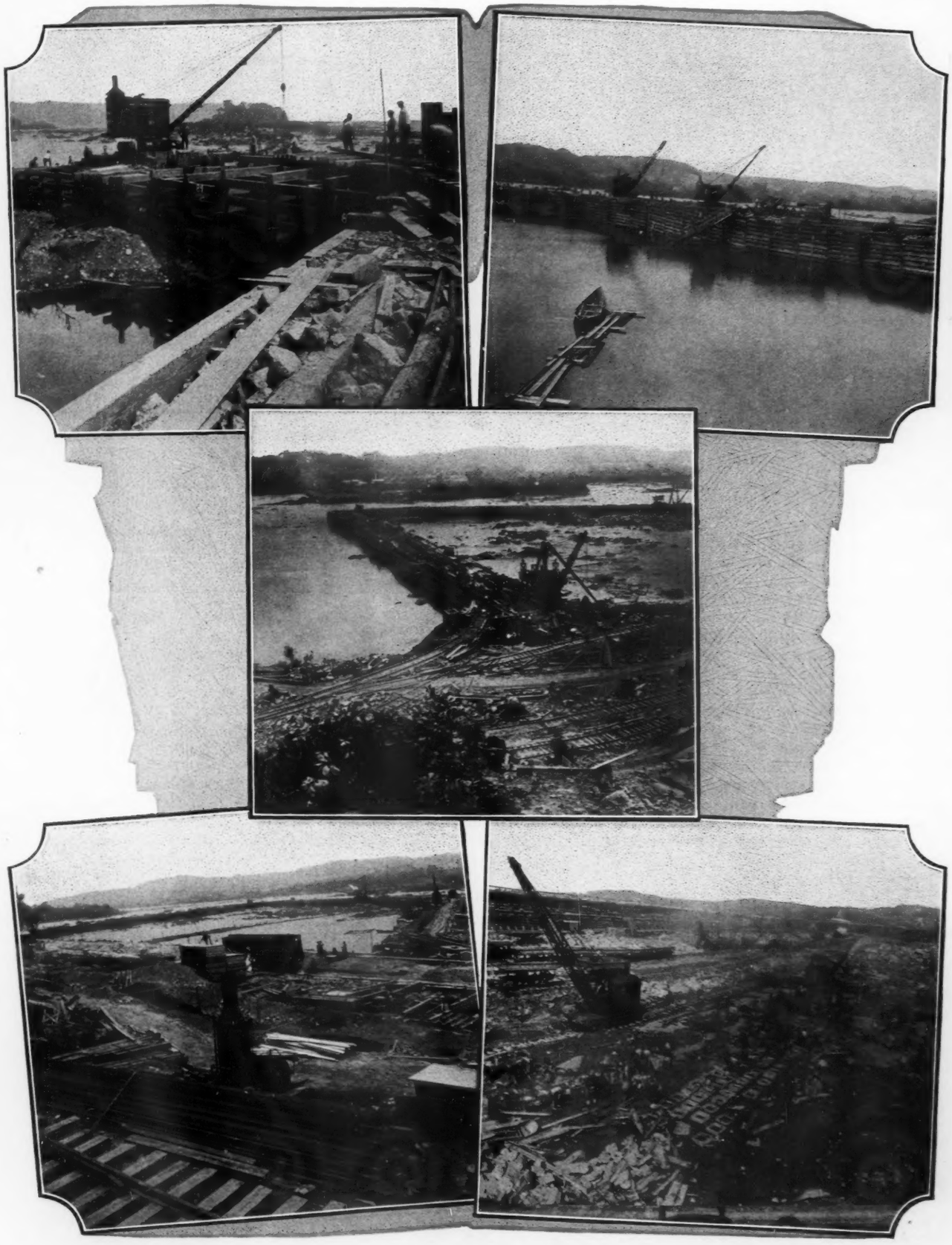
The camp of the Arundel Corporation is located on the east bank of the river where it will be convenient to the work incident to the relocating of the railroad and close to the site of that part of the dam which will be built by that corporation. The camp of Stone & Webster, Inc., is on the west bank of the Susquehanna and near the powerhouse section of the undertaking—this being the part of the development which that engineering company will construct. The primary task for each of the contractors consisted of erecting cofferdams outward from the west and the east shores, respectively, of the river in order to lay bare the rocky bed of the stream preparatory to clearing away loose boulders on the site of the dam foundation. These cofferdams had to be constructed rigidly enough to resist the thrust of the river at flood periods while leaving a gap in the middle of the stream of sufficient width to form a fairly free channel for the river to flow through at all stages. Some of our illustrations show the general character of these cofferdams and the manner in which they were built.

Within the cofferdam, on the east side of the stream, the contractor was not required to excavate any great amount of rock to provide a satisfactory footing for the dam foundation: it was necessary to remove only loose boulders, to get rid of any rotten rock, and to clear out crevices so as to provide proper surface contact for the concrete to be poured there. Air-driven paving breakers were successfully used in this clearing or cleaning operation. In the construction of the cofferdams, numerous woodborers and air hammers were utilized in preparing the timber for assembling and in driving driftbolts, etc. Clay diggers were also helpful in disposing of the earth overburden lying upon the rock.

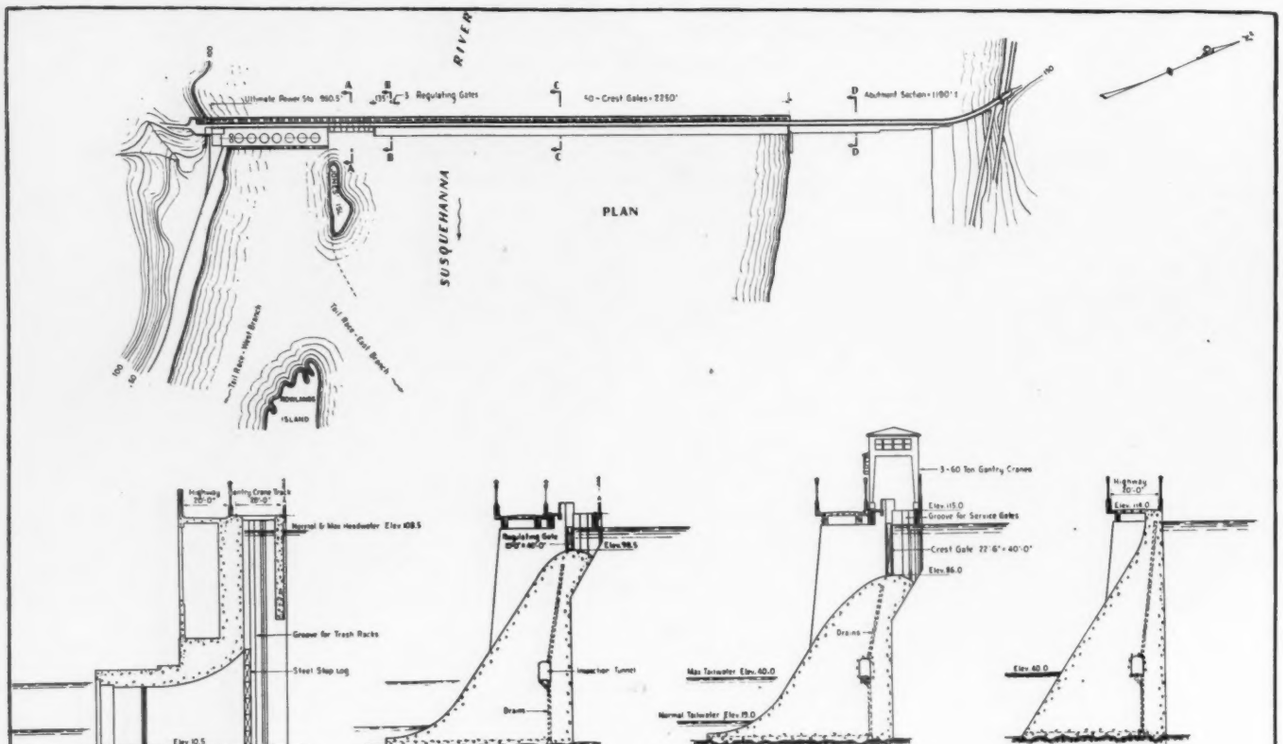
Within the area laid bare between the two cofferdams on the west side of the river, the



Perspective sketch of the complete Conowingo Hydro-Electric Development. Insert is a photograph of the bridge that will be removed before the pool above the dam is filled.



Activities at the west side of the river during the building of the cofferdam and afterwards when the area within the cofferdam was unwatered.



General plan and sections of the Conowingo Dam.

contractor will be obliged to excavate all told approximately 400,000 cubic yards of rock in preparing the foundation for that section of the dam and in excavating the tailrace for the various waterwheels. Perhaps we can make plainer what the excavating of this amount of rock means if we point out that it would be enough to form a rectangular column more than 17,000 feet high having a cross section of 25x25 feet. Again, the rock would be ample to provide a bed 18 inches deep for a splendid highway 25 feet wide having a total length of nearly 55 miles! In the excavating of this rock at the powerhouse site X-71 drifters and numerous DCR-23 "Jackhamers" are playing an important part.

A substantial portion of the rock removed in preparing the powerhouse site and the tailrace will be crushed and utilized as aggregate in the concrete required in constructing the dam and the powerhouse. A total of 650,000 cubic yards of concrete will be needed for these structures. Again, in order that the reader may have a better understanding of the volume of material required, let us say that 650,000 cubic yards of concrete would make a monolithic mass 59 feet square having a total height of 7,020 feet—in other words, be 1⅓ miles high. It is only when we keep in mind these momentous figures that we begin to realize the magnitude of the work in hand at Conowingo—work that will utilize the potential power in the water of the Susquehanna, thus conserving coal and saving a considerable investment in a steam plant of equivalent capacity.

Work at Conowingo is going forward at a promising rate; and current should be available in Philadelphia from that source during 1928. The reservoir that will be formed upon the completion of the dam will have a maximum draw-down capacity of 2,500,000,000 cubic feet. By using the generators at Conowingo only at peak-demand periods during stages of low stream flow, the plant at Conowingo will be able to carry the peak load in the Quaker City and replace at least 190,000 Kw. of steam-plant capacity. On the other hand, when the flow is ample, the Conowingo Station will be equal to taking over the entire base load of Philadelphia for stretches of weeks at a time—the steam plants in Philadelphia then being utilized only to help out at the peak periods. Employing the generators at Conowingo in this adaptable manner, it is understandable how that splendid hydro-electric station will effect a fuel economy equivalent to an aggregate of 750,000 tons of coal annually.

Where the present Conowingo Bridge joins the much traveled motor-car route. The site of this picturesque bridge will be submerged when the pool above the dam now building is filled with water.

India produces from 65 to 70 per cent. of the world's supply of sheet mica.

Calyx Drill Minimizes Famine Menace

By SIDNEY MORNINGTON

FULLY two-thirds of India's hundreds of millions of people are supported directly by agriculture and its associate activity, cattle raising. In other words, agriculture is India's primary industry, and such has been the case for a great many generations. As a matter of fact, it has been authoritatively computed that quite nine-tenths of India's inhabitants live directly or indirectly by the tilling of the soil.

The Calyx drill in service in India. The attendants are engaged in removing a core from one of these drills.

During favorable seasons, India's farmlands produce sufficient food for her dense population; but a lack or shortage of rain is apt to cause privation if not to lead to widespread starvation. To minimize the consequences of diminished rainfall and to conserve as far as practicable the run-off of the wet months, the British authorities have fostered extensive irrigation projects and have called into being a network of distributing channels through which conserved water might flow and reduce proportionately the likelihood of sectional famines.

Out of a total of 200,000,000 acres now sown with crops, substantially 50,000,000 acres are under irrigation. About 23,000,000 acres are irrigated by government and private canals, and 7,000,000 acres by artificial pools. More than 14,000,000 acres are irrigated with water that is raised from 10 to 60 feet by primitive machinery that is operated either by hand or by cattle power, and only a small part of the water is moved by pumps or other mechanical means. On the face of it, then, one of the greatest opportunities for the improvement of agricultural conditions lies in the utilization of modern pumps and wells in order to extend the boon of irrigation.

With this recognition of existing conditions, it should be easy for anyone unfamiliar with India to recognize the far-flung benefits that can be realized by the spreading among her farmers and her regional authorities of a knowledge of the facilities now made available by engineering concerns for the handling and the distributing of water from different sources. To this end, there was held at Poona some months ago what was officially called the Bombay Presidency Agricultural Show.

Among the different apparatus and equipment displayed there, none attracted more attention than the Calyx core drill—designed to drill deep wells through rock—and the air lift which makes it possible to raise water to the surface from underground sources that cannot be tapped by many of the familiar types of pumps. Incidentally, it might be pointed out here that what is known as famine boring is one of the activities confronting the governmental authorities every now and then. Famine boring is merely the sinking of wells to more or less great depths in order to obtain a supply of water when the resources at the surface are woefully inadequate.

Work of this nature in the Bombay Presidency is under the supervision of the district agricultural engineer, who employs no fewer than 14 Calyx drills for well boring throughout that presidency and the Province of Sind. The presidency is making strenuous efforts to prevent the recurrence of famines which have so often devastated India and produced

At the last agricultural show at Poona, India, American machinery enjoyed a prominent place and attracted much attention.

great distress. Large funds have been allotted for famine boring; and His Excellency Lord Irwin, the new viceroy of India, is keenly interested in everything affecting the agricultural prosperity and well-being of the Empire. His Excellency Sir Leslie Wilson, governor of Bombay, is no less heartily absorbed in the problem. For instance, the gigantic Sukkur Barrage has his continual attention; and to Sir Leslie is mainly due credit for the Bombay Presidency Agricultural Show—the largest and most successful exhibition of its kind ever held in India.

The two Calyx drills displayed won the gold and the silver medals offered by the management; and, to add to the interest of the spectators, actual borings were made and cores brought to the surface to show just how these American-made machines cut their way through solid rock as they work their way downward to subterranean water-bearing strata.

In connection with famine boring, the Calyx drills commonly bore 6-inch holes below the bottoms of existing large wells that are usually something like 30 feet in diameter. These 6-inch holes tap sands carrying soft water at points perhaps hundreds of feet below the big wells; and the water so reached rises into the wells from which it is withdrawn by means of such primitive agencies as bullock hides and goat skins, much as was the custom in Biblical days. When the water does not rise to amplify that in the existing wells, then it can be raised to the surface of the ground by means of the air lift—compressed air supplanting the moving parts of mechanical pumps in accomplishing this operation.

To prove the commercial soundness of the process developed for the extraction of oil from coal, full-sized plants are to be equipped in various parts of Great Britain by a company formed for the purpose and organized under the name of the L & N Coal Distillation, Ltd. The chairman of this company claims that by their low-temperature process of distillation it will be possible to obtain from a ton of coal 20 gallons of oil, 6,000 cubic feet of illuminating gas, and from 1,568 to 1,624 hundredweight of smokeless coal that is better for home and industrial consumption after than before treatment.

The gas industry of the United States distributes its product through a network of 87,000 miles of mains.

The air valve on this simple pneumatic switch-cleaning apparatus is placed within easy reach of the operator's right hand.

Cleaning switches with compressed air in one of the yards of the Southern Pacific Company.

COMPRESSED AIR KEEPS SWITCHES CLEAN

SWITCHES and switching points in busy railroad yards and terminals must be kept clean, if accidents are to be avoided. As a precautionary measure, every trainman is compelled after throwing a switch to make certain that a union has been effected. Only then is he permitted, by standard railroad rules, to carry his train over the switch.

Switches of this type are comparatively easy to keep clean. But the more complicated mechanical switches, that are thrown from a tower, cause more trouble because of their greater number of moving parts. They are harder to get at; and even a slight accumulation of grease and dirt is apt to interfere with their proper functioning.

To do this work of cleaning expeditiously and thoroughly, the Southern Pacific Company has devised a combined blower and scraper that is employed wherever electro-pneumatic switches are in service. This cleaning tool consists of a piece of ½-inch pipe flattened at one end to form a nozzle and provided at the other end with a valve that permits the operator to control the flow of compressed air. Air is used at a pressure of from 70 to 80 pounds, and this is drawn through a length of rubber hose connected at convenient points to the main air-supply line.

Equipped with blowers of this description, workmen in certain of the yards of the Southern Pacific system have experienced no trouble in keeping the switches thoroughly clean. By means of the nozzle end—which also serves the purpose of a scraper, the men can readily loosen any grit-carrying grease, etc., and then remove it, together with any accumulated sand, gravel, or cinders, with a strong blast of compressed air.

Extending New York City's Subways

Describing Operations on a Typical Section of the Eighth Avenue Line

By C. H. VIVIAN

THE line of the new Eighth Avenue Subway now being built in New York City extends for 10½ miles along the western side of Manhattan Island. The Board of Transportation has divided the route into sections, approximately half a mile long, each of which is covered by a separate contract. Although conditions and problems vary widely in a stretch of this length, some of the contracts involve such a diversity of operations as to include virtually all the different types of construction that characterize the entire undertaking.

Such a section is the one extending along Fort Washington Avenue from 174th Street to 184th Street. While it is but 2,740 feet long, its construction calls for excavating by the cut-and-cover method, for the driving of several types of tunnels, and for the sinking of three vertical shafts of varying depths and of one inclined shaft. This section, which is designated officially as Section 7 of Route 78, is being built by the Del Balso Construction Corporation. Work was begun on it early in 1926.

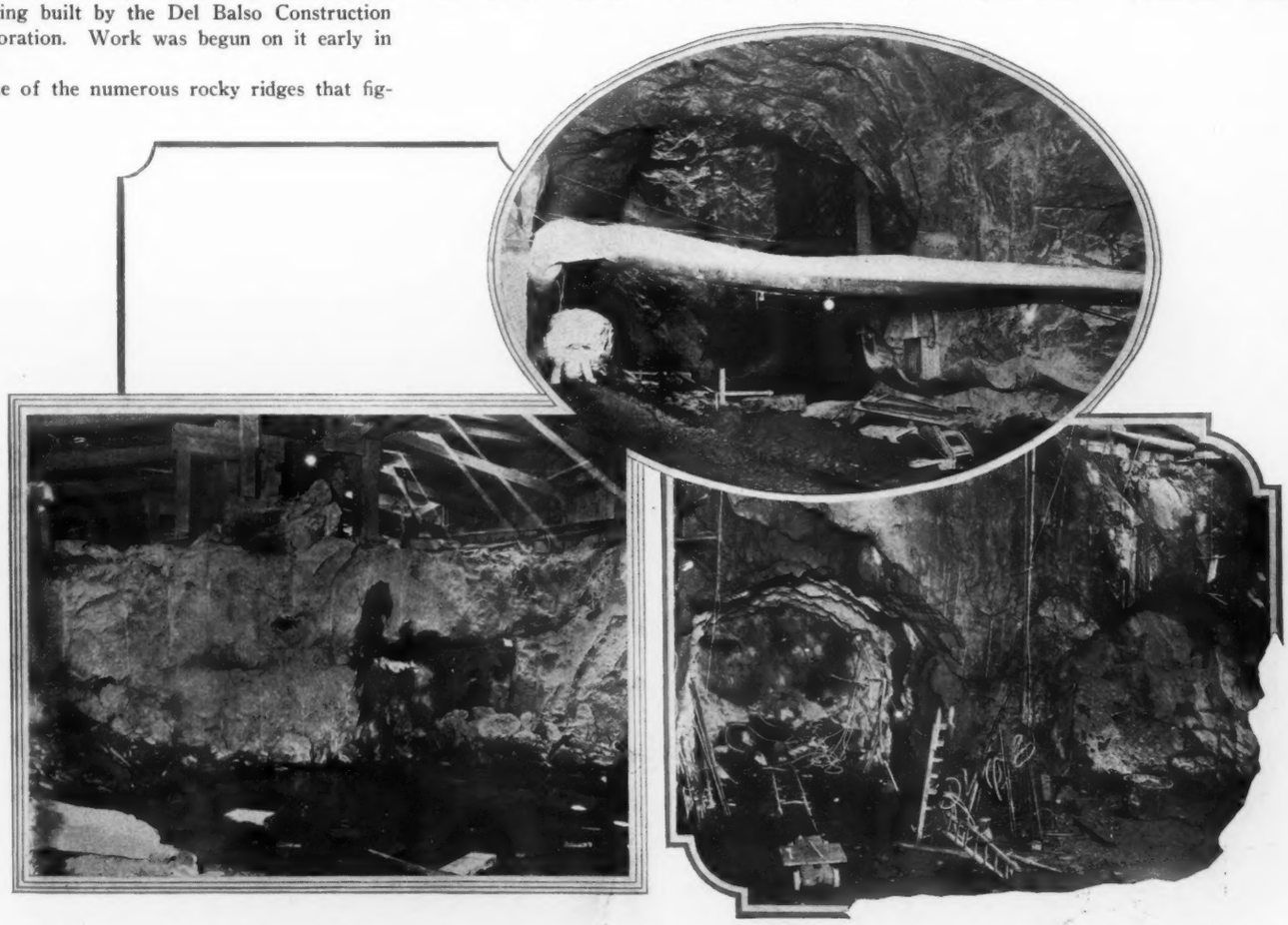
One of the numerous rocky ridges that figure so prominently in the topography of Manhattan Island is found in this area. A line drawn along its crest would fall pretty generally within the boundaries of Fort Washington Avenue, which has a north and south course. The apex of the ridge—between 183rd and 184th streets—is the highest ground in Manhattan.

This elevation, during the Revolutionary War, was the site of Fort Washington, which was relinquished to the storming Hessian troops on November 16, 1776, after a gallant defense by Colonial soldiers. It was repossessed by the American Army, under General Washington, upon its triumphal entry into New York in 1783. The unearthing of cannon balls by subway workmen gives evidence of the strenuous warfare waged there.

In the southern portion of the section under consideration, the ridge rises gently from south to north, making possible excavating by the cut-and-cover method. Farther north, however, the surface gains elevation more rapidly, and at 179th Street the track grade is 48 feet below ground level. Tunneling starts at that point and continues northward to the north line of the section, where it connects with a tunnel included in the adjoining section.

The eastern limb of the ridge has a comparatively gradual and uniform slope until a point between 183rd and 184th streets is reached. From there northward, the side falls abruptly away from the crest and forms a bluff, with Fort Washington Avenue running along its top and Overlook Terrace—200 feet to the east and approximately 125 feet lower in elevation—at its base.

This topographical condition has proved especially favorable to the contractor. The plan for the finished subway calls for a passageway entering this bluff just south of the 184th Street line and at right angles to the track line. By driving this adit as a preliminary operation,



Top—Looking out of the adit and into the lower portion of the elevator shaft at 184th Street. Collapsible jute tubing is used to convey fresh air into the tunnel.
Left—Rock was encountered a few feet below the street surface in the cut-and-cover work. "Jackhamers" were used to drill the bench.
Right—Starting the twin-tunnel section. At this point the core wall is 14 feet thick.

a means was provided for loading the excavated material directly into trucks. This speeded the work and eliminated the expense of hoisting spoils to the surface of Fort Washington Avenue.

The 2,740 lineal feet of construction covered by the contract is made up of 1,007 feet of cut-and-cover work and 1,733 feet of tunneling for a standard 2-track subway. A station, 660 feet long and having a mezzanine 620 feet long, is specified at 175th Street and northward in the open-cut portion. Three types of tunnel are called for. These consist of 151 feet of twin bores with a rock wall between; 871 feet of 2-track tunnel having a width of 33 feet; and 711 feet of 2-track tunnel widened to 56 feet to accommodate a station, extending from 181st Street to 184th Street, 27 feet high to provide for a suspended mezzanine. The last-mentioned station is to be served at the south end by an escalator and stairway and at the north end by elevators and by the lateral passageway previously referred to. A part of the elevator shaft is to be used for ventilation. Two other ventilating shafts are specified: one near 181st Street and one between 179th and 180th streets.

Muck pile at the breast of the large-size tunnel, showing the column set-up for the R-72 drifters.

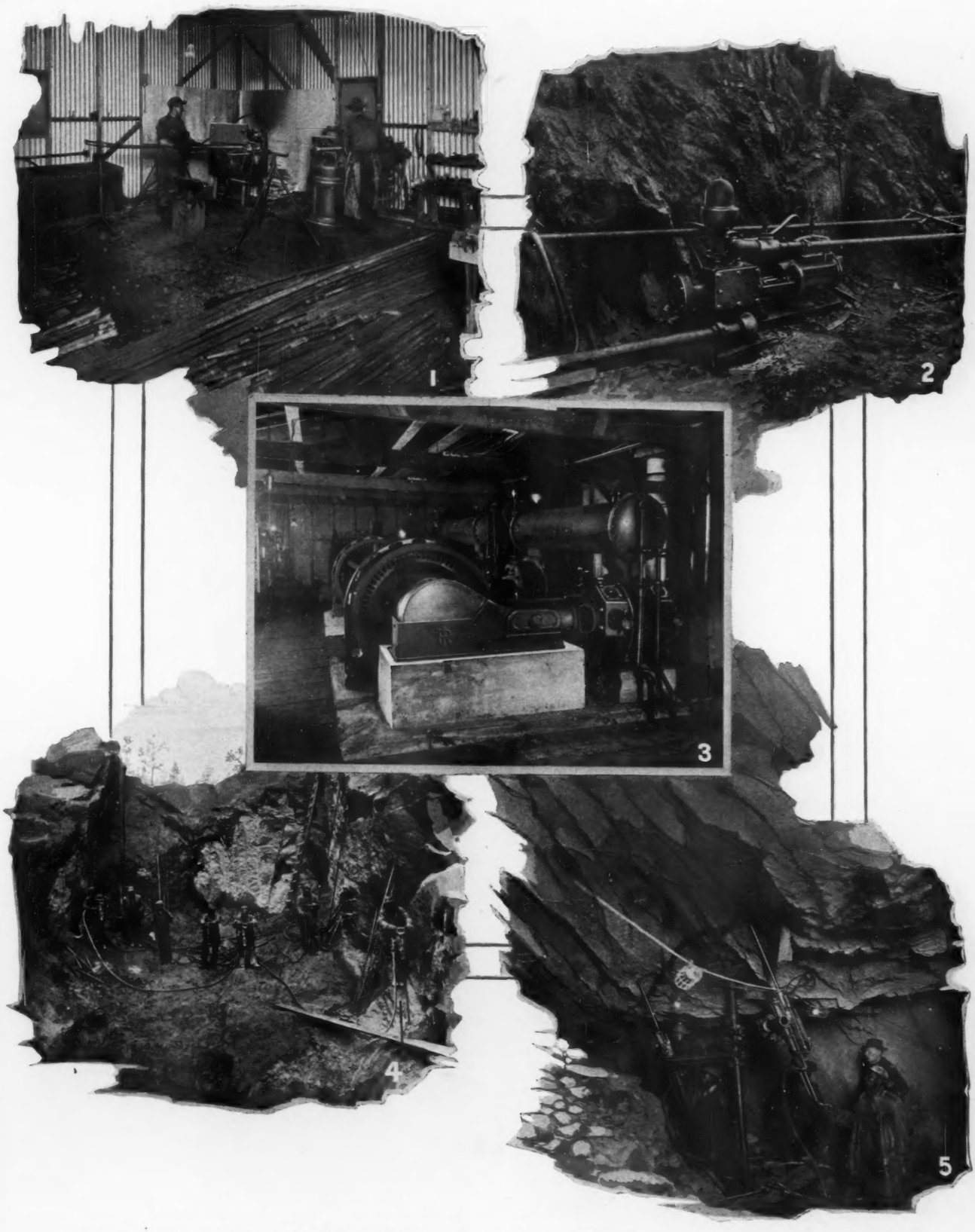
On May 1, more than 50,000 cubic yards of rock and about 20,000 cubic yards of earth had been removed from the open cut and 50,000 cubic yards of tunnel excavation had been completed, these quantities being nearly 90 per cent. of the estimated total. The muck is trucked to the Hudson River just south of Fort Washington Point, where it will help build up municipal land that is expected to become highly valuable in the future. A well-organized plan of operation and the use of dependable machinery have enabled the contractor to make rapid progress to date; and the indications are that the work will be completed in considerably less than the 42 months allowed from the time of delivery of the contract.

As a major portion of the work is in rock, the part played by compressed-air drills is important. Compressed air also is serving to operate other essential machinery, including power shovels, paving breakers, drainage pumps, and equipment for the reconditioning of drill steels. A plant for producing the required air was established at Fort Washington Avenue near 183rd Street, from where piping was laid to the various points of use. Four PRE-2 compressors, each driven by a 225-H. P. General Electric motor, are installed. These machines have a combined capacity of 5,400 cubic feet of free air per minute, which is used at a pressure of from 90 to 100 pounds. They are equipped with Type VK aftercoolers and with Maxim silencers. The only expenditure so far in the nature of upkeep or replacement has been for the purchase of a reserve set of gaskets. No occasion for using them has yet arisen. The blacksmith shop and the carpenter shop are situated on Overlook Terrace, near the portal of the adit. Drill steels are heated in No. 25 oil furnaces and reconditioned by No. 50 sharpeners.

While the compressor plant and other essential equipment were being assembled, work was started at the south end of the section on the cut-and-cover excavation. The CC-35 type of paving breaker was selected as the speediest and the most economical tool for breaking up the street surfacing—compressed air for their operation being furnished by two Type 20 portable compressors.

The usual procedure of opening up half the

Left—Elevator shaft and adit at 184th Street.
Right—Where the adit enters Overlook Terrace at 184th Street. Steelwork for the elevator shaft in course of erection.



1—Reconditioning the drill steels with an oil furnace and a No. 50 sharpener.

2—Cameron pump, operated by compressed air, employed to clear the workings of water.

3—Three of the four PRE-2 compressors which are supplying the necessary operating air used by the contractor.

4—"Jackhamers" at work in sinking the shaft at 184th Street.

5—Starting a raise for an elevator shaft with "Leyner" drifters.

Left—One of the air-operated shovels handling muck in the tunnel.
Right—Steam shovel at work in a decked-over cut.

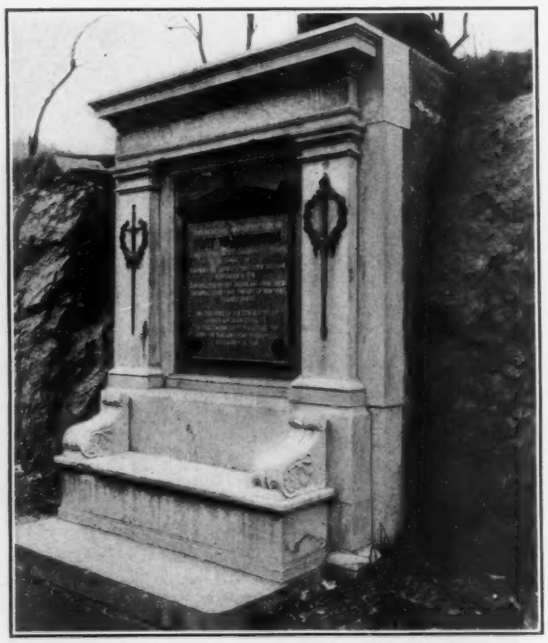
width of a street at a time was followed to keep the thoroughfare open to traffic. The initial lift or depth of excavation varied from 10 to 14 feet. The material was hand loaded into skips, raised, and dumped into trucks by hoists mounted on caterpillars. After half the street had been opened up in this fashion for a distance of from 60 to 75 feet it was decked over and the adjacent strip next attacked. When the initial excavation had been carried to a depth of approximately 5 feet, a 30-inch girder, 60 feet long, was laid parallel to the street line and 6 feet from the center of the street. Eighteen-inch steel girders were then placed crosswise, spaced 10 feet apart. At the street-side end these girders rested on 12x12-inch timbers, laid longitudinally with respect to the street, while at the other end they cantilevered 6 feet over the 30-inch girder. Stringers of 6x12-inch timber were put on top of the 18-inch girders; and, finally, 5x10-inch decking was arranged crosswise and at right angles to the stringers.

When the other half of the street was opened up, this procedure was duplicated —the 18-inch girders being spliced at the center of the street to form single girders extending the width of the excavation. As the cut was deepened, timber supports—assembled in general after the manner of square-set timbering in mines —were placed. This method of decking put the principal load of street traffic upon the two longitudinal lines of 30-inch girders, 12 feet apart and 12 feet from either side of the street. As the excavation grew in depth, these girders were supported at intervals of 50 feet by towers constructed of 12x12-inch timbers.

After the top lift had been taken out, the work of excavating the remaining material to grade was effected in two lifts, varying in depth from place to place. Ramps, having a grade of 15 per cent. entered the workings from the west side of Fort Washington Avenue at 175th Street and 177th Street. Steam shovels loaded the excavated material directly into 5-ton trucks. Two Bucyrus shovels were employed: one of 1-yard capacity and the other of 1½-yard capacity.

The depth of the excavation at the south end of the section was approximately 33 feet. It increased gradually towards the north end, where it was 48 feet. Rock was encountered from 3 to 6 feet below the surface, and from that zone downward drilling was resorted to. The general method was that of benching—the down holes being placed with DCR-23 "Jackhamers" and shot with 40 per cent. dynamite.

The width of the cut-and-cover excavation is approximately 50 feet, while the width of the street is 80 feet. However, at the south end, the subway line veers over until it touches the property line on the west side. This was done to give a better alignment in making a turn to the east that starts at that end of the section. The contractor was therefore required to underpin a number of buildings. The underground work also included the proper handling of a 12-inch water main, sewers on either side of the street, gas mains, and various wires serving telephone and lighting systems. All these were suspended from timbers placed just under the street decking.

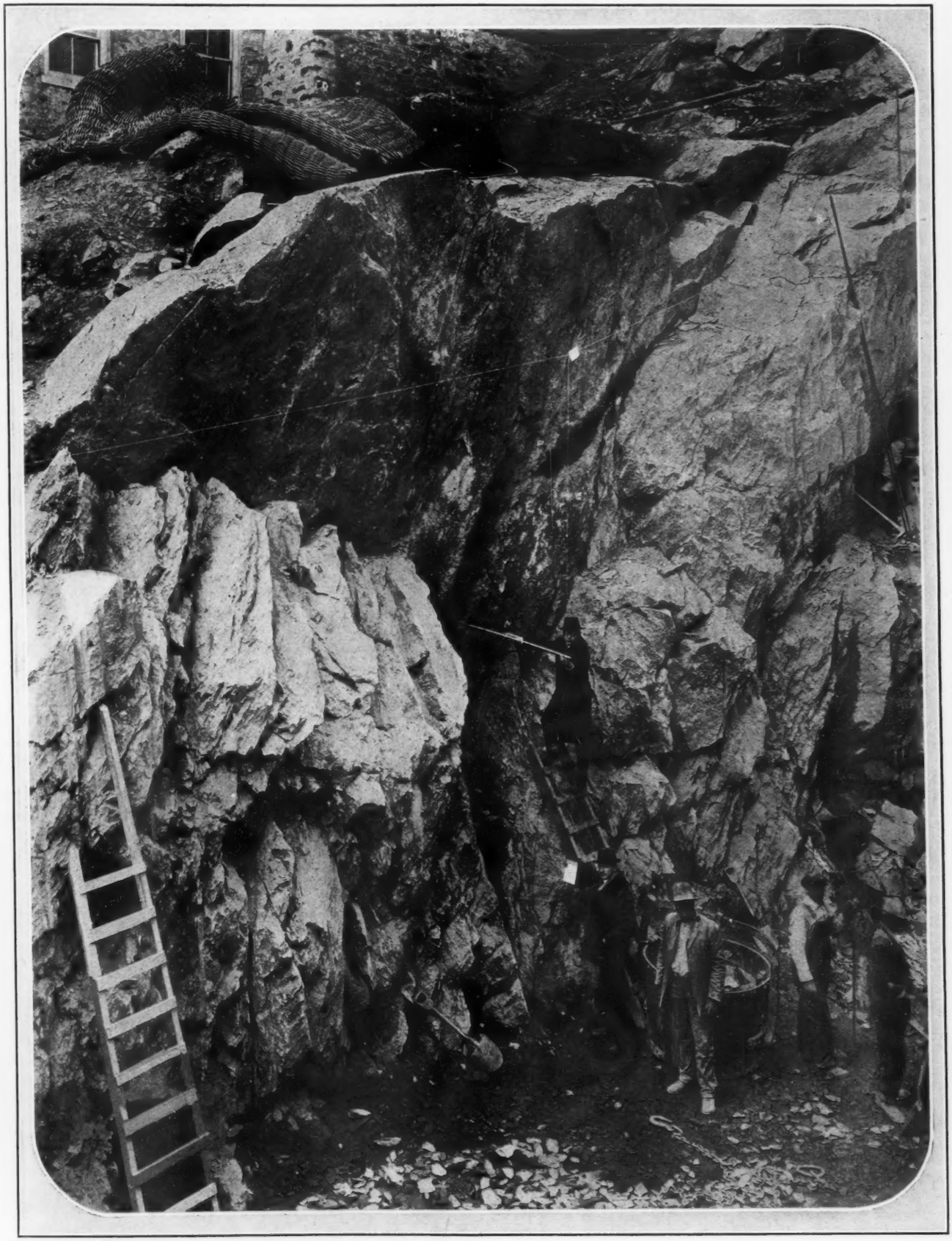


Tablet marking the site of Fort Washington.

As was previously set forth, the key to the tunnel excavation was the adit driven into the hillside at the north end of the section. This adit is roughly circular in cross section; approximately 14 feet in diameter; and enters the bluff on a down slope of about 6 per cent. It was started in March, 1926, and reached the east boundary of the subway line—a distance of 128 feet from the point where ground was broken—in the following month. The adit was then continued across to the west line and enlarged between the two subway lines to full tunnel size.

The turn towards the south, to drive the subway tunnel proper, was made on June 21, 1926. The breast of this tunnel, for a distance of 663 feet, was approximately 50 feet across and 24 feet high, with minor variations from place to place. The excavation was carried to line on the east side, but on the west side from 6 to 10 feet of rock was left in place to be taken down later. An average of approximately 4 feet also was left at the bottom to be subsequently excavated to subgrade. The tunnel roof is arched—the plans calling for an additional excavation of 2 feet where the roof and the side walls meet in order to form a notch for keying the concrete roof arch.

The contractor was favored with firm, hard rock, practically free from fractures and fissures. This eliminated the need of timbering, and enabled the work to progress at a good rate of speed. It also served to make the tunnel comparatively dry. The small quantities of water that entered the workings were pumped out—among the equipment used for this purpose being 3 Cameron GSS units operated by compressed air.



Measuring the space left when a large boulder broke loose at a joint plane near the top of the 184th Street elevator shaft. Michael Del Balso, head of the contracting company, is on the ladder. Below him, holding the line, is A. A. Chaimson, section engineer for the Board of Transportation.

The tunnel was driven by the top-heading method—the top heading having a height at the center of from 10 to 12 feet, leaving a bench of approximately 14 feet. The top heading was at all times one step in advance of the bench, thus making it possible for the drilling crews to keep ahead of the mucking.

A typical top-heading-drilling schedule called for the placing of 148 holes. Except for 10-foot cut holes at the center, these were 8 feet deep. As a considerable portion of the contract price constituted payment for the excavating of the tunnel sections, the matter of choosing dependable and economical drills was of prime importance to the Del Balso Corporation. The decision reached after investigation was to standardize on Ingersoll-Rand R-72 drifters for the heading work and on DCR-23 "Jackhamers" for the bench operations.

The drifters were mounted on double-screw columns, 10 feet long and 3½ inches in diameter, placed vertically. Two arms, each holding a drill, were used with each column. By erecting 7 columns it was possible to operate 14 drills at the breast simultaneously. The drifters were fitted with hollow, round steels having 4-point, 14- and 5-degree bits.

Two rows of vertical holes, each containing 15 holes, were drilled in the bench, one row near the front and the other at the back. A row of 14 shallow holes was also drilled into the base of the bench at an angle, there normally being a projecting transverse ridge at that point due to the fact that the previous round of shots did not shear the back of the bench off cleanly to the tunnel floor. These bench holes, totaling 44 for a typical heading, were placed with "Jackhamers" using 1-inch, hollow, hexagonal steels with 4-point bits.

For a heading such as has been described the schedule called for the drilling and blasting of one round of holes each day, of two 8-hour shifts, and also for the disposal of the resulting muck. The average advance per round was 7½ feet; and the material excavated amounted to 325 cubic yards. One of the accompanying diagrams shows in detail the procedure followed in blasting. The bench was shot first, there being 3 rounds of firing. The shooting of the heading was divided into 18 rounds, from 7 to 10 holes being connected in each round. A central cut was first made, and the rock was then broken towards it.

Sixty per cent. dynamite was used in all tunnel blasting; and the firing was done with electric current. One group of holes was loaded and shot at a time. Thus there were involved 21 separate loading-and-blasting operations in each round of drilling. The interval between shots averaged about 23 minutes; and approximately 8 hours elapsed between the firing of the first and the final group of holes. The powder consumption averaged a trifle more than 2 pounds for each cubic yard of material broken down.

Mack trucks with dump bodies were driven into the workings through the adit and backed to the muck pile. Loading was done by a Type 30-B, 10-ton Bucyrus shovel fitted with a 1½-yard dipper. A Bucyrus 1-yard machine was also employed in the tunnel. These shovels were so equipped that they could use either steam or compressed air. When operating in the tunnel, compressed air was employed—the boilers serving as air receivers; and, to insure clearance, the booms of the shovels were shortened to 12 feet and the dipper sticks to 10 feet.

Left—Decking in place over the street and one of the sidewalks.
Right—Sinking a ventilating shaft near 181st Street.
Bottom—Section of Fort Washington Avenue under which the tunnel runs.

For a time, the material left on the west wall was slabbed down while the breast was being drilled at a point ahead. In this work, R-72 drifters, mounted on columns, were utilized to drill holes 14 feet deep and parallel with the tunnel line. The 1-yard shovel was used for loading the muck shot down in the slabbing operations. An average of between 40 and 50 truck loads of spoils was handled in a day, each truck load containing approximately 3 cubic yards. The best record for a day was 72 such truck loads. By the methods described, the tunnel heading was advanced as much as 144 feet in a month—the highest figure for one week being 36 feet.

Until the tunnel line was advanced to meet the first shaft to the south, trouble was had with foul air due primarily to carbon monoxide in the exhaust from the trucks and, in lesser measure, to powder smoke. To better this condition, a blower was set up outside the adit portal. This blower was operated by a 20-H.P. motor and supplied 8,000 cubic feet of air at 5 pounds pressure per minute. The ventilating air was carried to a point near the breast through 16-inch, collapsible jute tubing which could be readily taken down at advanced positions during blasting.

The southernmost 48 feet of the large tunnel called for excavating to a width of 61 feet, with a flat roof—the additional space at the sides being required for various station structures. South of the large tunnel for a distance of 871 feet, where the plans call for a standard 2-track tunnel, the heading was 33 feet across and 20 feet high. The drilling was done there in the same manner as in the larger heading, except that the more limited space allowed only 10 drifters to be set up at a time. One of the accompanying drawings shows the details of the drilling-and-blasting method followed. The material was excavated to line on both sides, thus obviating the need of subsequent slabbing operations. The rate of advance was rapid—amounting to 210 feet during one month.

This smaller type of tunnel was carried only as far as the shaft between 179th and 180th streets, further progress from the north being blocked by the erection of steel within the shaft. Subsequent tunneling operations were conducted from the south end, at the point of junction with the open-cut work. For a distance of 151 feet toward the north, twin tunnels were driven. They are separated by a core wall ranging in thickness from 14 feet at the south end to 6 feet at the north end. Beyond that point, the 2-track tunnel begins.

These twin tunnels, which are 17 feet wide and 17 feet high with an arched roof, were driven during the spring of the present year. The same drilling methods were employed as in the larger tunnel sections, with four R-72 drifters operating at a heading. A Hoar shovel, operated by compressed air, loaded the muck into skips placed on car trucks which ran on 30-inch-gage tracks. From the tunnel portal, the skips were hoisted on to trucks, at the surface, by means of a crane, on caterpillars, in the street above.

On May 1, 1927, there still remained to be excavated approximately 300 feet of 33-foot tunnel—estimated to involve the removal of about 6,000 cubic yards of rock. In addition, there was about 4,000 cubic yards to be taken from the tunnel bottom, for track runways, and in generally trimming to line at various points.

The 3 vertical shafts were sunk with "Jackhamers," the practice being to make a cut and to blast toward it by benching. The spoils were hand loaded into skips and hoisted to the surface for dumping into trucks. The largest and deepest of the shafts is the one at 184th Street. It is 46x24½ feet in cross section and approximately 123 feet deep. This shaft has been lined with concrete and steel, and projects above the shaft collar far enough to allow for a street-level entrance. One side of the finished shaft will serve as a compartment for 3 elevators, while the other side will be used as a ventilating shaft.

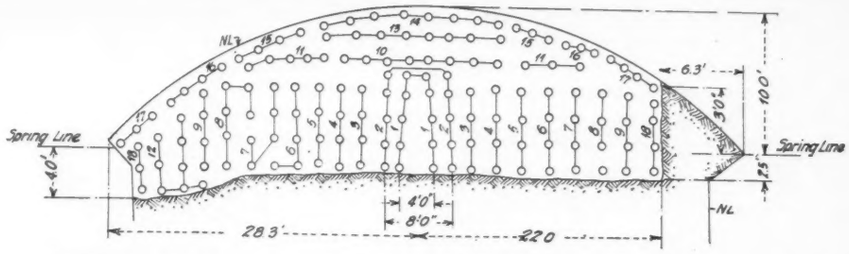


Diagram showing the location of the drill holes in the top heading of the large-size tunnel, as well as the grouping of the holes for blasting and the sequence in which they were fired. The heading had an area of 544 square feet. Each drill round broke down approximately 151 cubic yards of rock. More than 500 pounds of 60 per cent. dynamite was employed in loading the 148 holes.

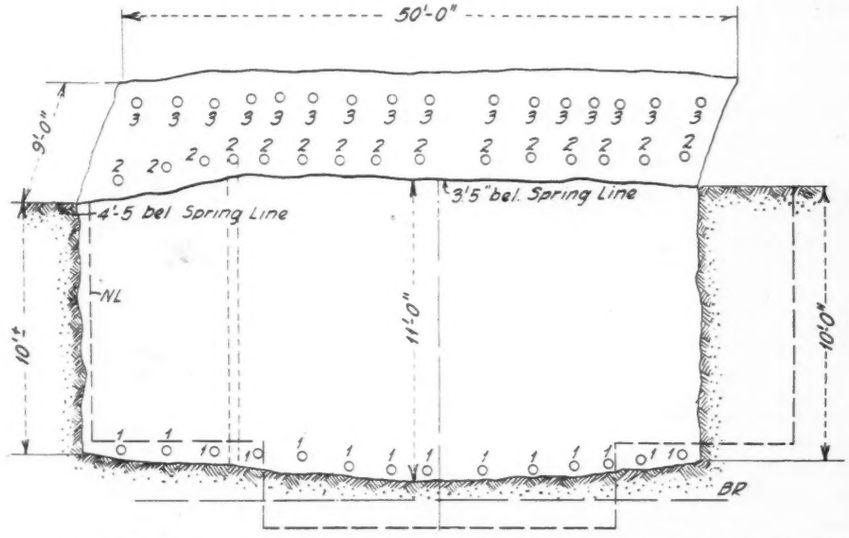
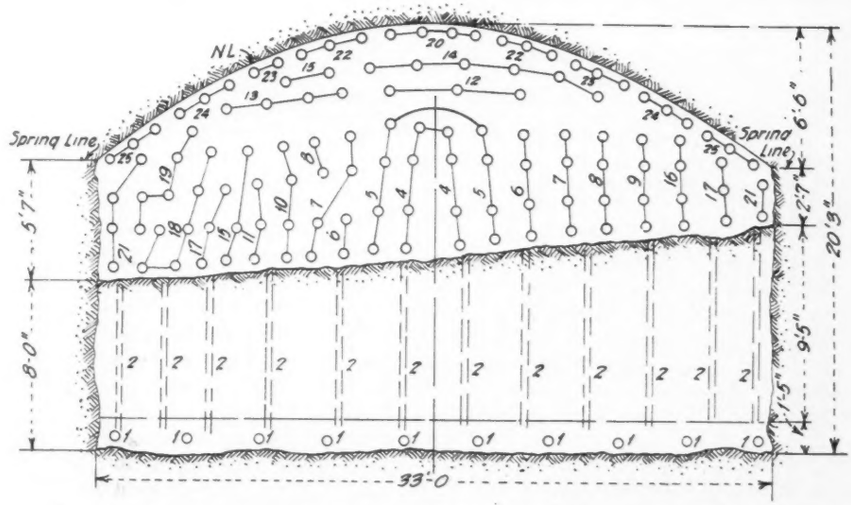


Diagram showing arrangement of the bench holes in the large-size tunnel and order of their firing. The No. 1 group of holes removed the bottom of the previous bench. A bench of these dimensions contained 175½ cubic yards of rock and called for the use of 125 pounds of powder.

The 181st Street shaft has a cross section of 25x14 feet and is 90 feet deep to track level. It opens into a chamber which will extend for 195 feet beneath the surface and will be covered with grating. The shaft between 179th and 180th streets is 31x15 feet in cross section and about 60 feet deep. It will contain an emergency stairway. Spaces connecting with its upper portion were provided for a fan chamber, as well as for ventilating openings which



Blasting diagram for a typical top heading and bench in the 33-foot tunnel. Holes for the third shot were drilled at the back of the bench, in line with the No. 2 group of holes. Such a round of 120 holes broke down approximately 155 cubic yards of rock requiring slightly more than 2 pounds of powder per cubic yard.

will be covered with gratings for a distance of 50 feet along the west side of the street.

The escalator shaft driven at 181st Street was a stoping operation. Using R-72 drifters, mounted on columns, the drillers opened a small passage along the 75-foot line which extended to the surface on a slope of 30 degrees. This will be enlarged to a 15x29-foot cross section.

All that portion of the section coming under the head of cut-and-cover excavating is being finished with steel and concreted according to the standard form adopted for the various subways of the city. Much of this work has been done, operations having been started at the south end and carried progressively toward the north. On top of the station and mezzanine portion, backfilling to depths of from 5 to 13 feet must be done. Between the station end and the beginning of the tunnel segment, the backfill depth will be from 20 to 27 feet.

The first concrete that was used in the southern end of the section was mixed near the points of use in a 2-bag mixer and placed in Blaw-Knox metal forms. In April of this year a central mixing plant, having a daily capacity of about 300 cubic yards, was installed in the elevator shaft at 184th Street. Here, again, conditions favored economical and speedy operations by the contractor. The mixer, a 7-bag Rex type, was placed above the level of the adit into which the shaft opens, and above the mixer was installed a Blaw-Knox inundator plant.

The two shaft compartments above the inundator are used as bins for sand and for the coarse aggregate. Each bin has a capacity of about 300 cubic yards. Adjacent to the collar of the shaft there was built a shed of sufficient size to house 8,000 bags of cement. An 8-inch pipe chute runs from the working floor of this shed to the mixing plant below, while each of the bins opens directly into the inundator. Thus, all materials are fed into the mixer by gravity. The facilities provided for storage enabled the contractor to have cement, sand, and gravel delivered by barge loads to a point on the Hudson River within half a mile of the place of use.

This mixing plant supplies concrete for various parts of the work—trucks, loaded by gravity chutes, hauling it to the southern part of the section. They also deliver it to the shaft at 181st Street, where it is chuted below into a Ransome 14-foot concrete placer operated by compressed air. The placer will be situated there until blasting operations at the north end of the section have been finished, after which it is planned to put the placer directly below the mixing plant. The greater portion of the tunnel lining will be placed from that set-up.

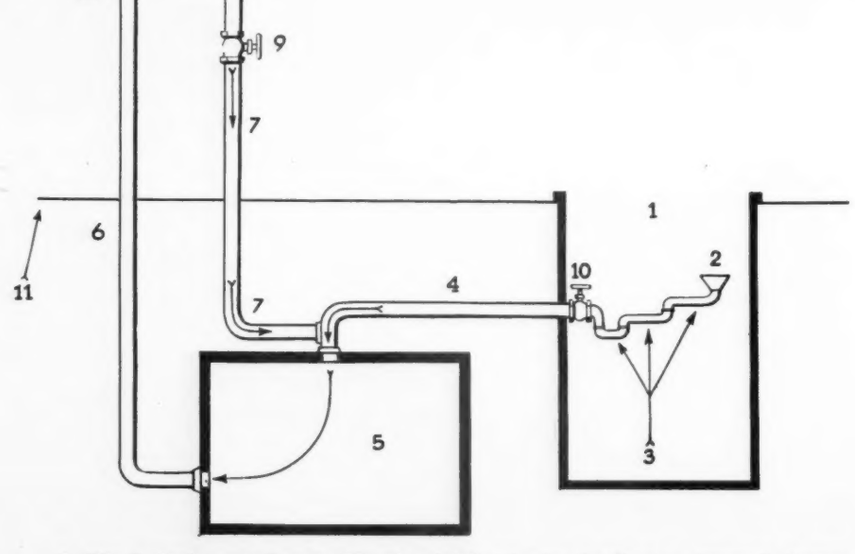
Approximately 28,000 cubic yards of concrete will be required for the section under consideration. The 2-track tunnel, where there is no station, will be finished in what is commonly referred to as the "umbrella" form. This calls for a wall between the tracks, with an arch above each track. The 181st Street station will be finished with a hanging mezzanine. In concreting the roof, steel plates will be placed 9 feet from either side of the roof center at intervals of 15 feet. Steel supports for the floor will be suspended from these by riveting. The elevators and the passageway at 184th Street and the stairway and the escalator at 181st Street will all open on to this mezzanine.

Michael Del Balso, the president of the Del Balso Construction Corporation, is a man of wide experience in handling large excavation contracts, the biggest piece of work that he has completed being the widening of Riverside Drive from West 157th Street to Dyckman Street. Raymond J. Van Wagner, a member of the contracting firm, is acting as chief engineer in charge of construction, with Edward J. Murphy as superintendent. A. A. Chaimson is section engineer in charge of the staff representing the Board of Transportation on the work.

COMPRESSED AIR SERVES TO DRAIN CRANKCASES

THE accompanying sketch shows how Alvin W. Schlechte, proprietor of the Schlechte Electrical Service, Granite City, Ill., has put compressed air to work in draining crankcases. In a concrete pit, which is located near one end of the "drive in" where it will not interfere with automobiles being served with gasoline, is a movable funnel-shaped cup into which the crankcase oil is drained. From there the oil flows through a pipe into a drum, whence it is forced by compressed air through another pipe into a receptacle in the repair room.

Before the oil will flow freely from the drain cup into the drum the air pipe must be closed by valve 8 and the surplus air released by way of valve 9. On the other hand, valves 9 and 10 must be closed when applying compressed air to force the oil out of the drum and into the discharge pipe. No trouble is experienced in carrying out this operation provided these various valves are properly manipulated. This use of compressed air in a garage has proved to be of practical help. It is a convenience, and it also saves valuable time both for the autoist and for the service man.



1, Pit; 2, drain cup; 3, movable pipe joints; 4, pipe leading to drum; 5, drum; 6, discharge pipe for oil; 7, air pipe; 8, 9, 10, valves; 11, ground level.

AIR-OPERATED GATES AT GRADE CROSSINGS

BY the use of diaphragm pneumatic gates, the Illinois Central Railroad has made it possible to control traffic at several street crossings from one tower and under the direction of one watchman. Thirty-nine crossings in South Chicago are now guarded in this manner; and the force of men required has been reduced from 111 to 57 for the 24-hour service.

Each gateman is stationed in an elevated tower, which gives him clear vision not only of the nearby crossing but also of those a block removed in either direction along the track. The mechanical equipment of the tower consists of a motor-driven air blower which exhausts air at any desired pressure up to 14 pounds.

The air is piped to the gates, which are of the arm type and which descend from either side of the street to form a barrier at the crossing. The air is fed to the gates through 4-way cocks, enabling the watchman to admit air to one side of the diaphragms or cylinders and to exhaust it from the other. He can thus stop the gates in any position. The air-blower set is run only when the gates are in motion. As repairs and oiling come to less than $2 a year for each set, the operating costs are low as compared with other systems of gate control.

Modern Drilling Equipment In Quarry Greatly Increases Output

By S. G. ROBERTS

CRUSHED stone is a material that has been growing rapidly in importance during recent years because of the manifold uses to which it is put. In the construction of modern highways; in all sorts of building operations where concrete is employed; and in the ballasting of thousands of miles of the country's railroads, crushed stone is utilized extensively. It is therefore of economic interest to devise ways or means by which this rock can be produced in large quantities and at a satisfactory cost to all concerned.

Face of a quarry at Suffern, N. Y. Drilling "snake holes" with an X-70 drifter.

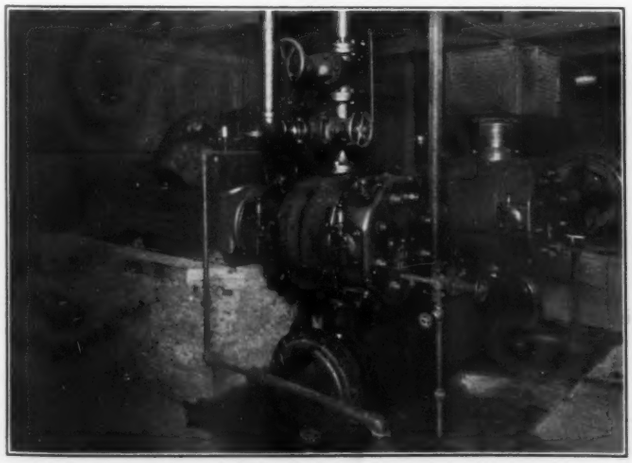
The present article has to do with activities at the Suffern Quarry, in New York State, of the Belmont-Gurnee Stone Company, where the employment of the latest types of air-driven rock drills has enabled the management greatly to increase the output while incidentally reducing expenses.

Prior to about two years ago, all deep vertical holes were drilled with well drills, and the toe holes were drilled with piston drills—"Jackhamers" being used to blockhole the large pieces of rock brought down by the primary blast. Operating in that manner, a drilling force of eight men was able to get out, during an open season, an average of 90,000 cubic yards of rock. Mr. Joseph A. Martin, the superintendent of the quarry, believed that this production could be increased considerably by the adoption of more up-to-date drilling equipment and that a greater tonnage of crushed trap rock could be disposed of profitably. The Suffern Quarry supplies a district lying adjacent to it within a radius of 15 miles. Within that territory, much crushed stone is used by the railroads, by the Public Highway Department, and by contractors doing all sorts of concrete work—in short, the demand for stone of this kind has been growing rapidly within the neighboring area.

After due consideration, Mr. Martin decided to scrap his former equipment and to purchase, instead, one X-70 rock drill, and two R-12 and two DCR-23 "Jackhamers." Air for operating these rock drills is furnished by an XRE-2 compressor; and the drill steels are kept in proper condition for effective work by a No. 50 "Leyner" sharpener.

Before adopting the X-70 drill for deep-hole work, much secondary drilling was necessary to break up the many big pieces of rock. Now, the primary blast breaks up the rock so effectually that most of it can be readily handled by the power shovel and sent directly to the crushing plant; and only a small percentage of the rock has to be blockholed with "Jackhamers." Twenty-two feet is the greatest depth of the vertical holes drilled with the X-70. One of our illustrations shows the same X-70 being used to drill "snake holes" at the bottom of the face of the quarry. The quarry face has a maximum height of 150 feet above the floor of the pit, and ranges from that height down to 100 feet at the low point.

The present working force in the quarry is only six men—two fewer than formerly; and this gang has been able at times to get out as much as from 29,000 to 30,000 tons of rock in the course of a single month. Between April 1 and October 1, last year, the quarry produced 132,000 tons of rock. In other words, the changed equipment has made it possible to reduce the labor charge and yet to get out much more rock than was formerly the case. The working day is of ten hours. The black-



Operating air for rock drills and for other pneumatic equipment is supplied by an XRE-2 compressor which is provided with a Midwest filter.

In the blacksmith shop of the Belmont-Gurnee Stone Company a No. 50 "Leyner" sharpener takes care of the drill steels.

smith sharpens about two sets of drill steels a day; and this man has to put in an average of only two hours daily in doing this work. Because he can thus quickly take care of the drill steels, he has much time left to do many other essential jobs around the plant.

From the quarry floor, the blasted rock is moved by trucks up a ramp and dumped directly into an electrically driven crusher, of the Farrell type, which is fitted with rolls 42 inches and 60 inches in diameter. The crushed stone is then run through the screens, which yield products ranging in size from ⅜ inch to 2½ inches. The personnel at the plant—including those in the quarry, in the mill, and in the office—totals 28.

Top—Office of the Belmont-Gurnee quarry at Suffern, N. Y. Mr. Joseph Martin, superintendent, in the doorway. Left—Crushing plant and powerhouse of the Belmont-Gurnee Stone Company. Right—Near view of the crushers.

PAN-AMERICAN RAILWAY NEARER REALIZATION

WHAT is said to be one of the greatest engineering feats in railroad construction was successfully concluded when the Southern Pacific of Mexico connected its rails at Salsu Puede Bridge, on the Jalisco-Nayarit state line, and thus put the United States in direct rail communication with Mexico and Central America. One can now travel from any point in the United States down the west coast of Mexico, through Mazatlan and Guadalajara, to Mexico City; connect there with the railway that goes to the Guatemala frontier; and then reach Central America by way of a narrow-gage road.

Work on this momentous railway project was begun and carried as far as the City of Tepic just before the outbreak of the Madero Revolution. From that time on until early in 1923 operations were at a standstill. Then, activities were again resumed; and in March of this year the line was completed at a total cost of $14,000,000.

The new link has a length of 161 miles; and for the most part runs along narrow paths cut in the sides of rugged mountains. Just what difficulties were encountered can be better understood when it is realized that within a stretch of 20 miles no fewer than 32 tunnels had to be driven, not to mention the several bridges that had to be built. One of these, the Salsu Puede Bridge, is 740 feet long and 240 feet high. All this work was accomplished only at an enormous expenditure of money and labor. Aside from the commercial advantages that will naturally follow as a result of this interlinking of the Americas, the route will undoubtedly become a favorite one with tourists because of its scenic beauty.

BASIC FACTS ABOUT BRICKS

DURING the year 1926, the United States Bureau of Standards, in coöperation with the Common Brick Manufacturers Association of America, has been conducting a series of tests on brick masonry which, from the size and number of test specimens and the control and measurement of variables, is noteworthy and unique.

While brick masonry is one of the oldest recorded types of construction, there has been practically no data upon which to base standards. This lack of fundamental information is probably largely responsible for the present unsatisfactory state of specification writing as applied to brick and for the wide variation in building-code requirements concerning brick masonry.

The investigational work is divided into two sections: the first involving a study of the properties of individual bricks, and the second the construction and the testing of solid and of hollow walls. The results obtained from the individual tests, correlated with the results obtained from the masonry tests, give information directly applicable to the formulation of standards and specifications for brick. As a matter of fact, some of the information obtained has already been made use of by one of our national societies devoted to standardization.

ELECTRICITY HELPING THE FARMER

SEVERAL novel applications of electricity have come to us from abroad where efforts are being made to encourage its use for agricultural purposes. Experiments have shown that fodder cut in the early spring, when it is frequently rainy, may be placed in a silo provided the fodder is sterilized. This can be done by permitting a current of electricity to pass through the silo for several hours right after it has been filled, and raising the temperature to 122°F. In this way it is possible to destroy the bacilli which otherwise would cause harmful fermentation. The current necessary to sterilize 100 tons of fodder is said to be not more than 1,000 kilowatt-hours, the cost of which is trifling as compared with the benefits obtained.

Another direction in which electricity is being utilized, although still on a small scale, is in heating the water in the beds where rice is first sown prior to transplanting. This application of electricity has produced very satisfactory results, as rice can thus be made ready for transplanting in less than 15 days as against about 45 days, as is now the case.

Oil Engine Effects Significant Economies

Drives Compressor That Furnishes Air to Operate Coal Cutters in Gaseous Mine

By A. S. TAYLOR

McALESTER, Okla.—a city of about 20,000 inhabitants, has reached its present size and prominence mainly because it is a center of coal-mining activities. Apart from the excellence of the coal mined nearby, McAlester's growth has undoubtedly been helped materially by the ease with which the coal could be shipped to ready markets. This favorable situation is due to the fact that the Chicago, Rock Island & Pacific Railroad and the Missouri, Kansas & Texas Railroad, respectively, bisect the town at right angles—thus providing ready access north, south, east, and west to points where the coal is continually in demand.

From the McAlester vein, as the coal measure is called, a high-grade bituminous coal is obtained that is especially hard and that also stores well. Or, as it has been well described, "the coal is a 'fancy looker,' and it does not lose its luster when exposed to rain or the atmosphere." A spur line, known as the "Samples Branch," taps the coal fields; and it is along this feeder to the "Katy" that a number of mines are located that get out coal from the McAlester vein. Among these operations is the mine of the Mullen Coal Company.

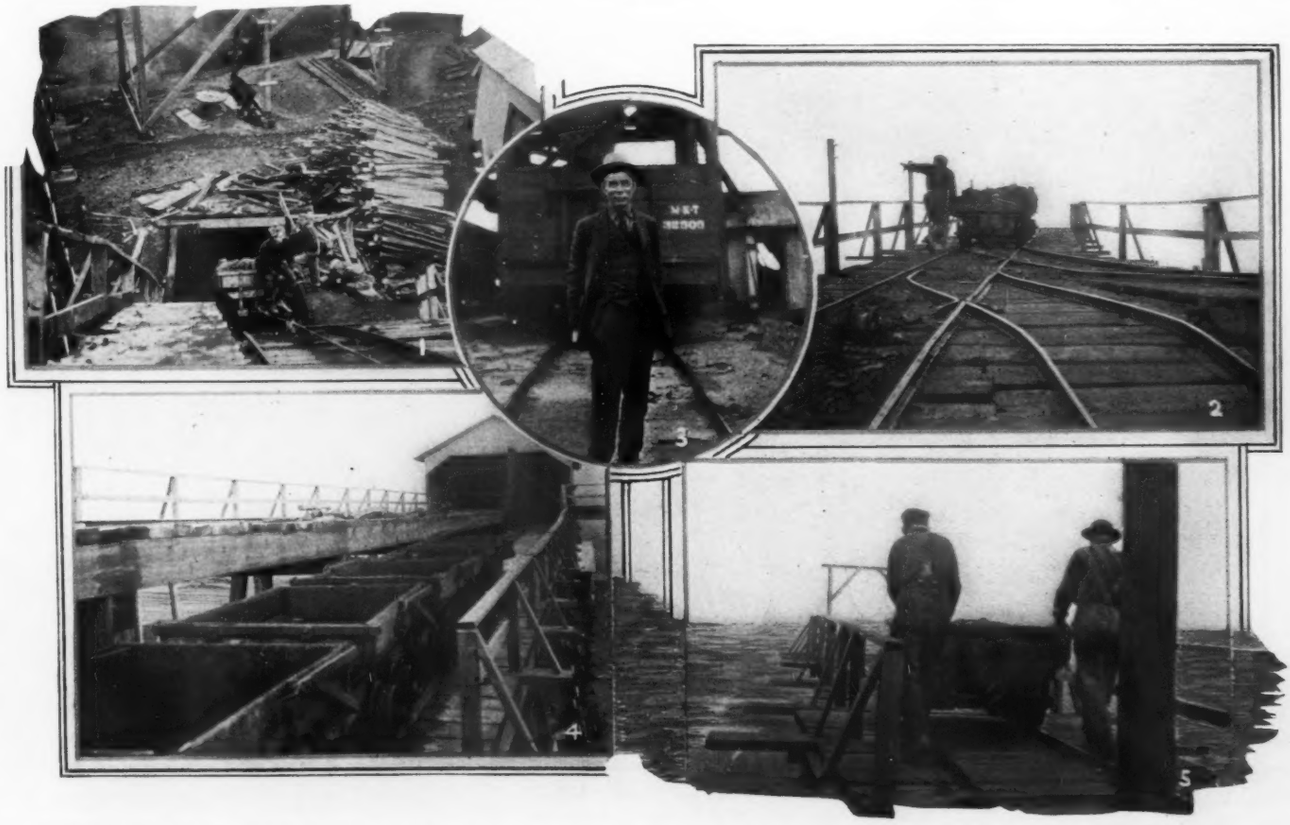
The operating lease under which the Mullen Coal Company works was obtained in 1899, when the eastern section of the present State of Oklahoma was still Indian Territory; and the lease was granted for a period of 30 years. There is every reason to believe that the leasehold will be extended. The property is situated on part of the State Penitentiary Farm; and the mine taps the extreme western end of the McAlester vein. The vein varies in thickness from 4 to 4½ feet and has an average pitch of 30 degrees—that is to say, the vein dips at 35 degrees at the top and is inclined about 26 degrees at the bottom of the mine slope—1,200 feet in from the pit mouth.

Generally speaking, the coal is mined by the room-and-pillar method; and substantially 55 per cent. of the coal available is recovered for marketing. Because of the sharp pitch of the vein, Radialaxe coal cutters have been found best suited for the work. The Radialaxe is an air-driven tool that works at any angle; and in the present case it uses octagon steels, 1½ inches in diameter, on the cutting end of which is a bit holder containing 5 bits or picks. The Radialaxe does only the undercutting; and, with this done, the coal is then broken down with charges of black powder.

The procedure is thus described by Mr. W. P. Mullen, president of the company: "After a room is mined, we drill 3 holes—one in the center and one in each rib. We cut the fuses so that the center hole goes first, and the two flanking holes follow. For the 3 holes we use about 4 pounds of powder. The reason we use powder and not dynamite is that dynamite, by its quicker action, would shatter the coal too much. Black powder, on the other hand, increases the percentage of lumps, and the coal in this state brings higher prices and stands handling better. This can be understood when it is recalled that all the coal is sized for commercial purposes."

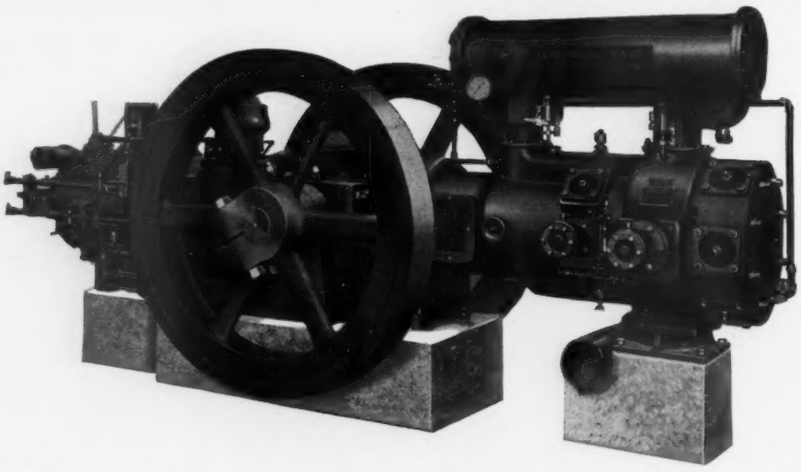
The Mullen Coal Company produces what is termed "lump," "nut," and "chestnut slack." The lump coal is that which will not pass through 2½-inch perforations; the nut coal is that coal that will pass through 2½-inch perforations but will not go through 1¼-inch perforations; and the chestnut slack is that coal that will pass through 1¼-inch openings in the screens. Much of this chestnut slack is shipped to Galveston where there is a good market for it.

The coal is hauled in 4-car trains up the slope



1—Pit mouth at the top of a 35-degree slope. 3—Mr. W. P. Mullen. 2—Crossover at the top of the tipple platform.
4—A train of empties coming from the tipple. 5—Shifting a loaded car on the tipple platform.

and on to the tipple—each car holding substantially a ton of coal. One by one the cars are run over a Phillips automatic cross-over dump from which the coal is dropped into a basket where it is weighed. Next, the coal passes over shaker screens—the lump coal going to a loading boom which, incidentally, serves as a picking table; and from this boom the coal falls directly into freight cars spotted beneath.



In this POC-2 unit the compressor is direct connected to a 110-H.P. oil engine so as to make the most effective use of the power developed.

As might be expected, it is necessary to practice operative economies in order to insure reasonable profits. Mr. Mullen says: "The problem is to handle a black business in a white way, and to meet the conditions imposed by Nature in a manner that will insure satisfying returns. This can be done only by employing modern methods and modern facilities."

Mr. Mullen has been in the coal-mining business well-nigh all his life; and had been operating at Savanna, Okla., 16 years before he took over the lease on which the Mullen Coal Company is now working. This ripe experience, no doubt, explains in part why he has been so successful in his present undertaking, and also makes it clear why he considers it worth while to employ thoroughly up-to-date agencies at this mine.

About a year ago, it became necessary to provide an air compressor of sufficient capacity to furnish operating air for the Radialaxe coal cutters adopted by Mr. Mullen for his mine. It was evident to him that the compressor desired would require motive power of not less than 100 H.P.; and the question was what should he choose as a prime mover. He was already operating a steam plant—burning coal from the mine—to generate steam to run the mine hoist and to operate the shaker screens which call for variable speeds; and he was using electricity for pumping and ventilating the mine. On the face of it, it seemed the logical thing to utilize either steam or electricity in connection with the compressor that had to be bought. Strange as it may seem, Mr. Mullen decided to turn to a third source of primary power—that is, to an oil-engine-driven compressor. In this unit the air cylinder is direct connected to the power cylinder. The oil-engine cylinder develops 110 H. P., which is sufficient power to drive the air cylinder which, at full load, delivers 500 cubic feet of air per minute at 100 pounds pressure.

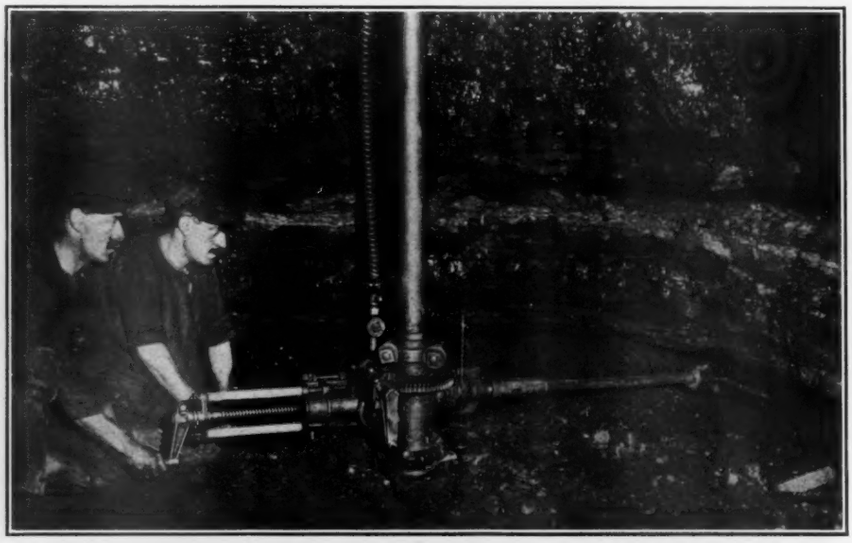
It would probably be of interest to many of our readers to learn why Mr. Mullen elected to buy an oil-engine compressor when he had coal at hand from his own mine that, at first blush, would seem to be the cheapest source of power. Furthermore, he already had in service a necessary steam plant which used coal from the mine. This steam plant contains two boilers that supply steam at a working pressure of 100 pounds and consume about 5 tons of coal during an 8-hour shift. Both boilers are in service daily. Therefore, to furnish the additional steam needful for a compressor requiring a 100-H.P. engine to drive it, Mr. Mullen figured that he would have to equip his steam plant with at least one more boiler of 150 H.P.; and that he would probably be on the safe side if he installed two boilers to make sure of constant service with steam maintained at an efficient working pressure.

According to his computations, the coal consumption for a steam-driven compressor would not be less than 5 tons a day — representing a fuel cost of $8.75. To this would have to be added a handling charge amounting to $2.50 a day; and the cost of operating the steam plant would be further increased by the attendance of a fireman whose pay would be $4.36 a day. Leaving out of consideration any expense incidental to the upkeep of the boiler or boilers, an addition to the steam plant would have necessitated making arrangements for an increased supply of water. Water obtained from driven wells in the neighborhood is too hard for boiler use; and the supply of surface water is decidedly limited. Furthermore, the district is subject to long dry periods. Accordingly, a minimum outlay of $15.61 a day would have been called for had a steam-driven compressor been chosen.

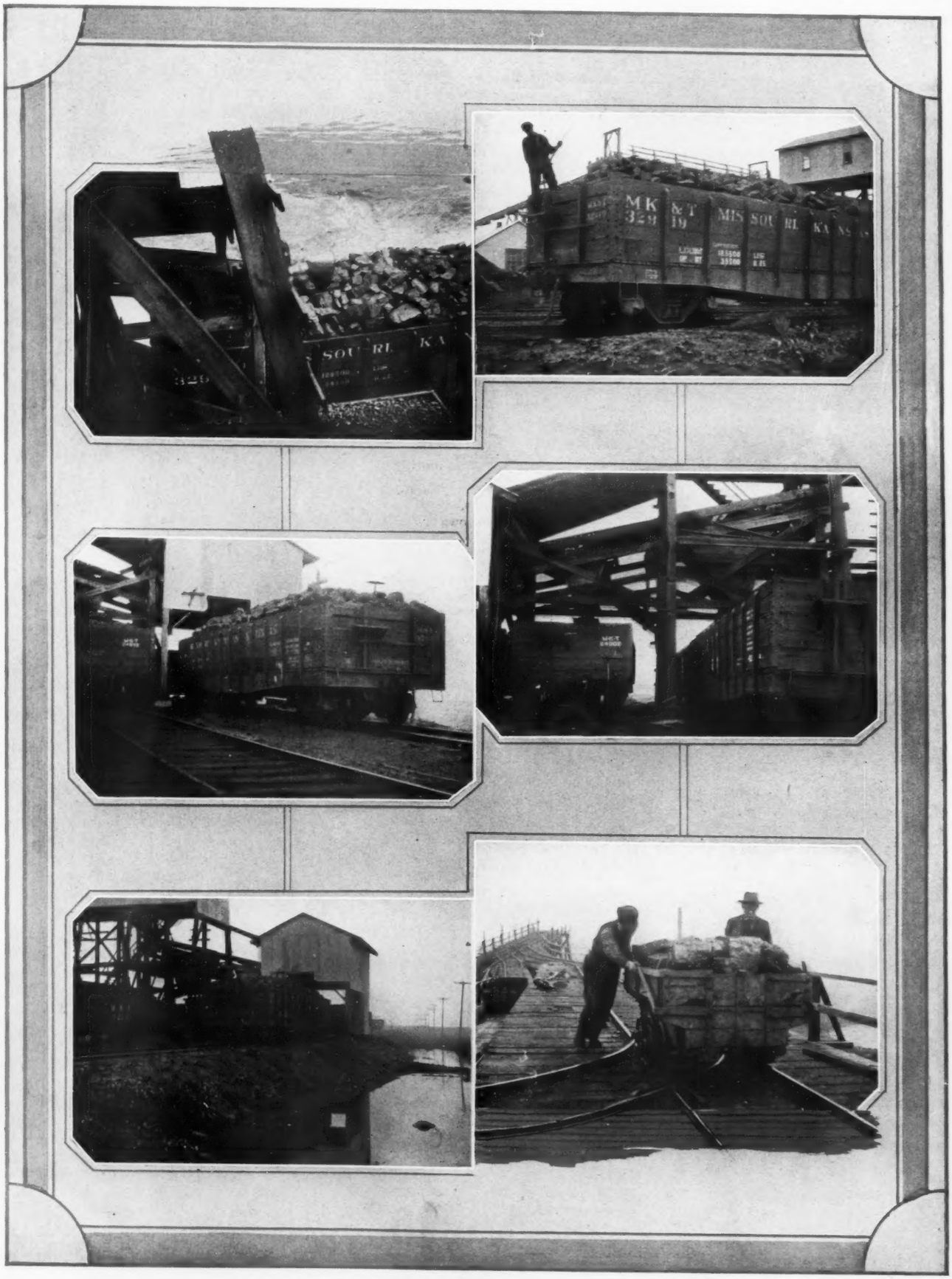
Having found it inadvisable to employ steam drive, let us see why Mr. Mullen decided against an electrically driven compressor unit, even though he was already using current to operate the pumps in the mine and the fans that force fresh air down into the underground workings. Perhaps it would be best to quote Mr. Mullen's own explanation:

"The electric company makes a demand charge of $1.50 per kilowatt—this charge being determined by the peak load of any 15 minutes of continuous service during a month. In addition to this demand charge, the electric company's rate is 2.42 cents for each kilowatt consumed. We figured that our average running period would be 16 days a month, and this would entail $7 a day for the demand charge alone; and when running under full load we would consume current that would cost us $1.90 an hour—making the total daily cost for electric current a matter of $22.20.

"An electrically driven compressor of like capacity and with a 104-H.P. slip-ring motor, laid on the ground at the Mullen Coal Company's mine, would have cost $4,500. The oil-engine-driven compressor, purchased instead, called for an expenditure of substantially $10,000—a difference of $5,500. Despite this difference we shall be able to save more than $3,000 a year, and thus wipe out the difference of cost in the course of less than 2



The Radialaxe makes it possible to cut a coal seam close to the floor.



Snapshots around the mine of the Mullen Coal Company.

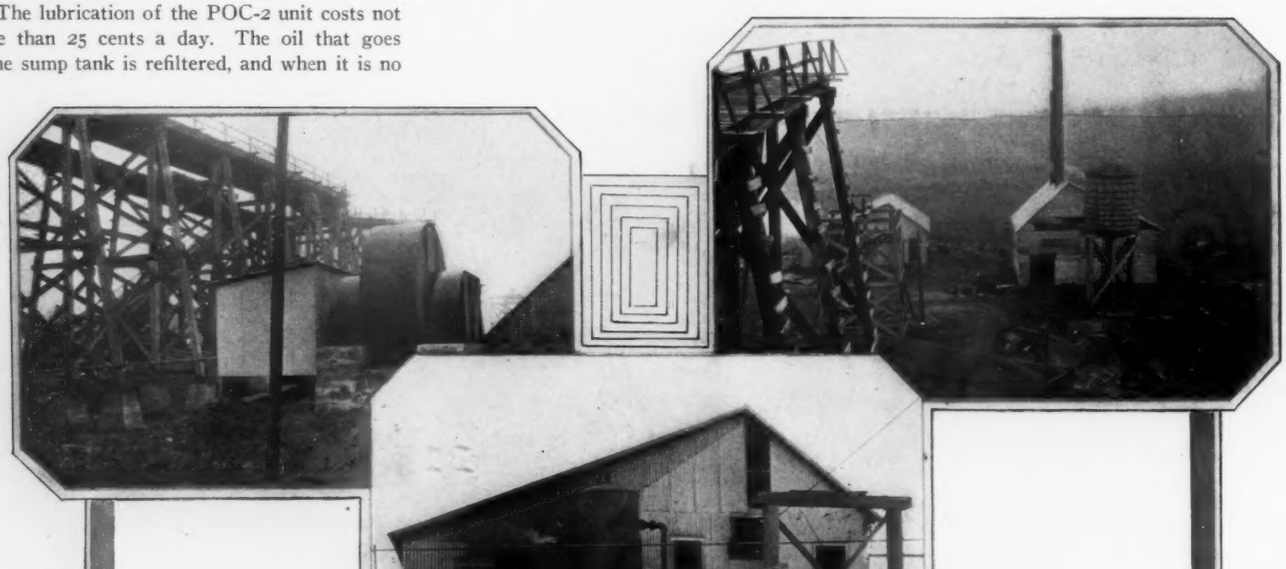
years and pay back in savings in less than 3½ years what the oil-engine-driven compressor has cost us! We can do this because the oil-engine compressor at full load consumes only 49 gallons of fuel oil a day; and we have been paying 6 cents a gallon for that oil. Working at our present rate of production, the POC-2 unit is using only about 30 gallons of fuel oil a day, making the total cost of operation between $2.00 and $2.25. Under full load, the cost would be about $3.20.

"Starting air for the compressor unit is furnished by a Type 15 compressor, direct connected to a Novo engine. This compressor provides starting air at a pressure of 225 pounds. The cost of operating this engine is so low that we do not give it consideration. We buy a 5-gallon can of gasoline at infrequent intervals, and that fuel lasts so long that we do not count it. The lubrication of the POC-2 unit costs not more than 25 cents a day. The oil that goes to the sump tank is refiltered, and when it is no longer fit for use in the engine it is utilized for other purposes.

"The operating pressure on the air line supplied by the POC-2 unit is 85 pounds. This air is delivered into the mine where it serves to drive the Radialaxe coal cutters. At the present time we are using 3 of these cutters; but when we are working to capacity we have 5 of these machines in service. Air, of course, is not consumed while the cutters are idle during the time required to shift steels or to move the Radialaxes from point to point, and this induces a load variation which the compressor is able to deal with in a very satisfactory and economical manner. If electric current were used for cutting the coal, we should have to pay the demand charge just the same during the intervals when the cutting machines were idle.

"We are satisfied that if anything should happen that would cut off our supply of electric current we could throw a belt on one of the flywheels of the POC-2 unit, and make our own electricity by hooking to a generator. This would enable us to supply current in an emergency to operate our pumps and our ventilating fans, which must be kept going continually because our mine is a gaseous one. Furthermore, we could place steam pumps in the mine and drive them with compressed air, if needful. The exhaust of the Radialaxes is beneficial, because it both cools and revitalizes the atmosphere of the mine; and air-driven pumps would contribute to the same end."

The Mullen Coal Company is now loading 125 tons daily, but it is so equipped that it can get out and ship 250 tons of coal a day.



Left—Electrically driven fan that provides air for ventilating the mine.
Right—Steam plant that provides power for the mine hoist and the shaker screens.
Bottom—Building in which are housed the mine hoist and the oil-engine compressor.

NOVEL SOURCE OF CURRENT FOR PEAK-LOAD SERVICE

THE problem of supplying the peak-load demand for electrical energy in thriving industrial communities without recourse to disproportionately costly reserve equipment is apt to prove a troublesome factor. While the linking up of central stations has done much to overcome this difficulty, still there are times when even a pooling of power of this sort is not equal to the requirements. Such is the situation facing Dresden, Germany, which has undergone marked industrial expansion in late years and has thus placed a heavy burden on the Municipal Electrical Works. At the close of 1920 there were 34,000 customers using 36,000,000 kilowatt-hours of electrical energy. Today, 100,000,000 kilowatt-hours are needed annually, and the consumers now number 75,000.

To meet this increasing demand for power, the city transmission system was linked with that of the Saxon Public Works, Inc., which virtually controls the supply of electric current in Saxony. This served for a time. But now, Dresden not infrequently suffers a shortage of power during the peak-load period when some of the large industrial consumers on the Saxon Public Works system take more than their accustomed measure of electricity.

In order to relieve the situation, the city council has planned an unusual hydro-electric storage plant at Niederwartha and Oberwartha, near Dresden. This plant consists of two huge reservoirs, one of which will be erected at an elevation of 460 feet above the other. The scheme is to raise the water from the Niederwartha reservoir into the Oberwartha reservoir in the night, when an excess of current will be available for the operation of the necessary pumps. During the hours of the day, the head of water thus created is to be used for the generation of an additional block of electric energy. Large turbines are being provided for this purpose. The City of Dresden will in this way be assured an ample supply of current for years to come even during the period of heaviest demand.

The annual conference and exhibition of the British Institution of Quarry Managers is to be held this year at Harrogate, England, from June 27 to July 1, inclusive. Heavy-oil engines are again to be a leading feature of the exposition, as engines of this type are becoming increasingly popular in quarries as a source of power.

Concrete Raised To Exceptional Height By Compressed Air

By ALLEN S. PARK

THE pneumatic method of placing concrete no longer comes under the head of new or novel operations. It has been used in almost every state in the nation; and, in the larger cities, it has been successfully employed for several years in the lining of tunnels, subways, and other subsurface conduits.

Thus far, however, its practical application has been largely confined to operations calling for the moving of concrete horizontally or in raising it to relatively moderate heights. It has been used, in the main, where the available working space would not permit the easy and quick handling of concrete by methods commonly employed in general construction work.

Concrete leaving the 6-inch pipe after being raised vertically to a height of 105 feet with compressed air.

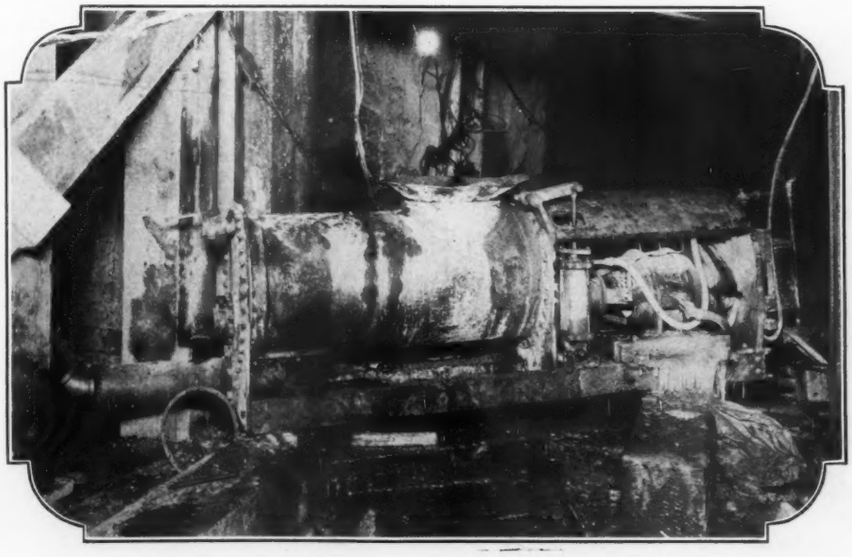
Recently, however, in an attempt to widen the field of application of the pneumatic placing of concrete, attention has been turned to the possibility of shooting concrete upward to considerable heights with air under pressure. In this connection, an interesting experiment was conducted in New York City by which concrete was successfully propelled with compressed air to a vertical height of 105 feet. While no effort was made to try out the method on heights greater than this, it is reasonable to assume from the data secured that the working limit, with the present equipment, is well above 105 feet.

The setting for the test was a shaft in one of the sections of the new subway now in course of construction in the Metropolis. A Ransome, horizontal-type, pneumatic placer, of 7 cubic-foot capacity, was stationed at the bottom of the shaft. This machine has been described in detail in a previous issue of this Magazine. An iron outlet pipe, 6 inches in diameter, was carried upward through the shaft. At its lower end were two bends of 45 degrees each, and at the top there was a single 90-degree bend from which extended a 20-foot horizontal section of pipe. The total length of pipe was, therefore, approximately 125 feet; and the bends aggregated 180 degrees, or two right angles.

Five batches of mixed concrete, ranging in bulk from 3 to 7 cubic feet each, were forced through this pipe system. The concrete was a so-called "subway mix"—the maximum size of the aggregate used being slightly in excess of 1½ inches. The mixing was done by hand; and the consistency of the concrete varied from semidry to sloppy.

The air, entering the machine through a 2-inch pipe, was obtained from the plant of the subway contractor, the Del Balso Construction Corporation. This plant consists of four PRE-2 compressors which are direct connected to synchronous motors. The normal air supply available is 1,500 cubic feet per minute. The gage at the placer intake registered 90 pounds pressure. This dropped sufficiently during the dispatching of the batches to make the average pressure used approximately 70 pounds. No facilities were at hand for measuring the amount of air consumed.

In every instance, the test batches were conveyed through the pipe without difficulty. As far as could be observed, there was no tendency towards clogging: all the material was carried through the pipe. The time required to send the maximum charge of 7 cubic feet through the line was 16 seconds. The timing was done at the machine; and the air supply was not turned off until the operator was positive that no more material remained in the line. The tests were witnessed by several engineers and contractors who were interested in the equipment as a possible means of placing concrete in the erection, for instance, of lofty, narrow bridge piers and other similar structures where established methods of operation are apt to prove slow and costly.



Pneumatic concrete placer in position at the bottom of the shaft.

It is suggested, for example, that a pneumatic placer could be erected on a standard boom-type paver, thus forming a portable concrete plant which could be moved about on a job with ease. Each concrete form could carry, on the outside, a pipe of suitable size, which could be extended upward as the work progressed. By making connection at the lower end of the pipe with the portable pneumatic placer, this

pipe would serve to handle all the concrete used. Such a method would, it is held, both speed up work and cut costs.

While considerable thought has been given to such a plan, engineers and builders were apprehensive that the passage of the air-impelled concrete through a pipe line attached to the forms would cause damaging and dangerous vibration and would present a constant hazard to the men working at the top. It also was feared that the concrete would be discharged with such force as to endanger both forms and workmen. The test conducted seems to indicate that these fears were not well founded. There was no perceptible vibration; and as the concrete was discharged in the form of a spray it gave no trouble.

The experiment showed that it might be possible to handle materials other than concrete by the pneumatic method. Mortar and plaster, for instance, probably could be elevated to considerable heights on construction jobs. So far, however, no study has been made of the comparative costs of handling such materials by this method or by those commonly used.

It has been proved in the case of a horizontal line that the concrete is carried entirely in the upper half of the cross section. While no evidence can be cited, it is the opinion of those familiar with the subject that, in the case of a vertical line, the concrete tends to travel along the walls of the pipe—the air using the central space for its passage.

It has been established that the success of pneumatic propulsion with the type of machine under consideration depends directly upon a sufficient volume of air at the proper working pressure. To assure satisfactory results, it has been determined that the minimum volume of air that can be used is 500 cubic feet per minute for the first 100 feet of discharge pipe and 1 cubic foot per minute for each additional linear foot. The initial charge of 500 cubic feet of air is needed to penetrate the batch of concrete in the placing-machine chamber, to fill the pipe line, and to start the batch on its way. The pressure specified is from 90 to 100 pounds per square inch. The speed with which the concrete travels through the pipe has been ascertained to be approximately 30 feet per second.

The conditions under which the vertical test was made indicate that cold weather has little if any effect upon the success of the method. The thermometer reading was 22°F.; and the pneumatic machine and the discharge pipe had to be thawed out before they could be used.

The first air-and-water mail service between Rotterdam and Java has proved thoroughly satisfactory. By the new route, the mail is carried by airplane from Rotterdam to Marseilles; thence by steamer to Sabang; and from that point on it is again transported by aircraft to Batavia and Soerabaya—effecting a saving of four days between Sabang and Batavia alone.

Nuevitas, on the north coast of Cuba, is the world's leading sugar port. According to *Commerce Reports*, it exports twice as much sugar as any other port handling that commodity.

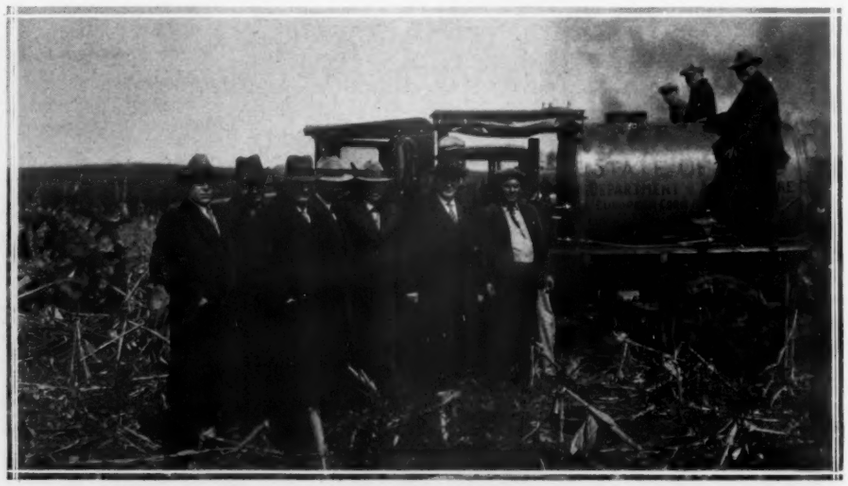
Governor Len Small of Illinois and his son, a Kankakee County farmer, viewing a demonstration of the equipment used to exterminate the European corn borer. The battle was staged by the joint forces of the Federal and the State departments of agriculture.

FIGHTING THE CORN BORER WITH FIRE

VIGOROUS measures have been taken by the State of Illinois to stamp out the threatened invasion of the corn borer. More than 50 men have been actively engaged in the battle that has been carried on in Kankakee County, in the upper part of the State, where the pest has intrenched itself. In conducting this warfare, there has been close coöperation between State and Federal officials, for it has been realized that, unless the spread of the European corn borer in this country is checked, the loss to agriculture throughout the great corn belt would prove a disastrous one.

In this campaign, crude-oil burners of special design have been used to give to the corn fields a baptism of fire—tank trucks, with air compressors mounted behind the drivers' seats, supplying oil under a pressure of about 200 pounds per square inch to the burners by way of long lines of rubber hose. These burners are light carts carrying a series of pipes through which the oil is forced. The rear end of the burner frame is about 20 feet across and is provided with jets like those on a gas stove. In operation, flames shoot downward from these jets, destroying whatever cornstalks or other vegetation may be within reach. It is claimed that the heat of this fire is so intense that no living organism can withstand its withering blast.

On May 9, Melbourne ceased to be the capital of Australia. On that date, with appropriate official ceremonies, Canberra became the Federal capital of the Commonwealth. Canberra is in the district of Yass, in the southern section of New South Wales, and was selected years ago as the most desirable site for the nation's seat of government. It should be of interest to Americans to learn that Australia's new capital is being laid out according to plans submitted by a Chicago architect.



Compressed air forces oil to the burners that are used with this outfit to destroy the European corn borer with searing flames.

Wonders Worked By Selective Flotation

Compressed Air Essential in Performing the Metallurgical Miracle That Has Turned Losses Into Profits

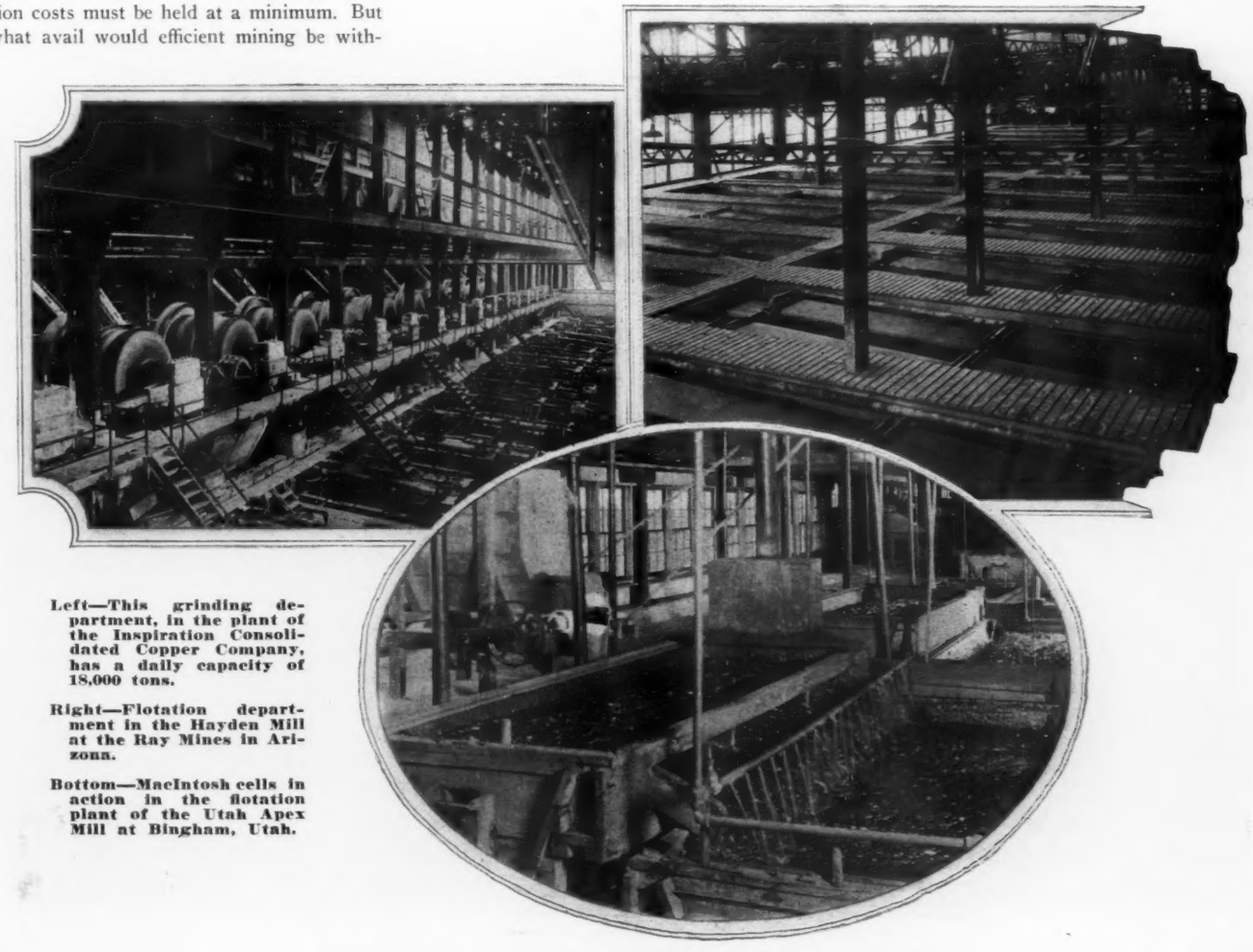
By GAIL MARTIN

WEBSTER'S dictionary defines froth as a "mass of bubbles resulting from fermentation, effervescence, or agitation: figuratively, anything of a light or unsubstantial nature." Yet froth is raising millions of tons of mineral each year from a condition of metallurgical disrepute to a state of high commercial value. Through the alchemy of science, an oily, fluffy, dirty-gray froth is separating complex sulphide minerals and segregating their component parts—zinc, lead, copper, silver, and iron—into valuable products. Difficult smelting problems have been overcome; waste has been converted into profitable ore; and all through the discovery that froth can be made to accomplish what no other known mechanical or chemical agency will do as economically or effectively.

The enumeration of the foregoing facts leads to an interesting observation. Let the fundamental importance of skillful mining be granted, inasmuch as it is conceded that production costs must be held at a minimum. But of what avail would efficient mining be without economical methods of converting ore into metal? Wherefore, it can be truly said that, in the last analysis, the prosperity of the nonferrous metal industry rests upon a substance as unsubstantial as froth.

Mining has but recently passed through a crisis that threatened its existence. Five years ago it was realized that the high-grade, desirable smelting ores had been nearly exhausted. Available reserves consisted of low-grade complex ores containing heavy percentages of zinc. As depth was attained, the zinc content increased. This was particularly true of the Rocky Mountain region where, today, there is practically no large deposit of lead-sulphide ore that does not have zinc associated with it and in amounts nearly equalling the lead content.

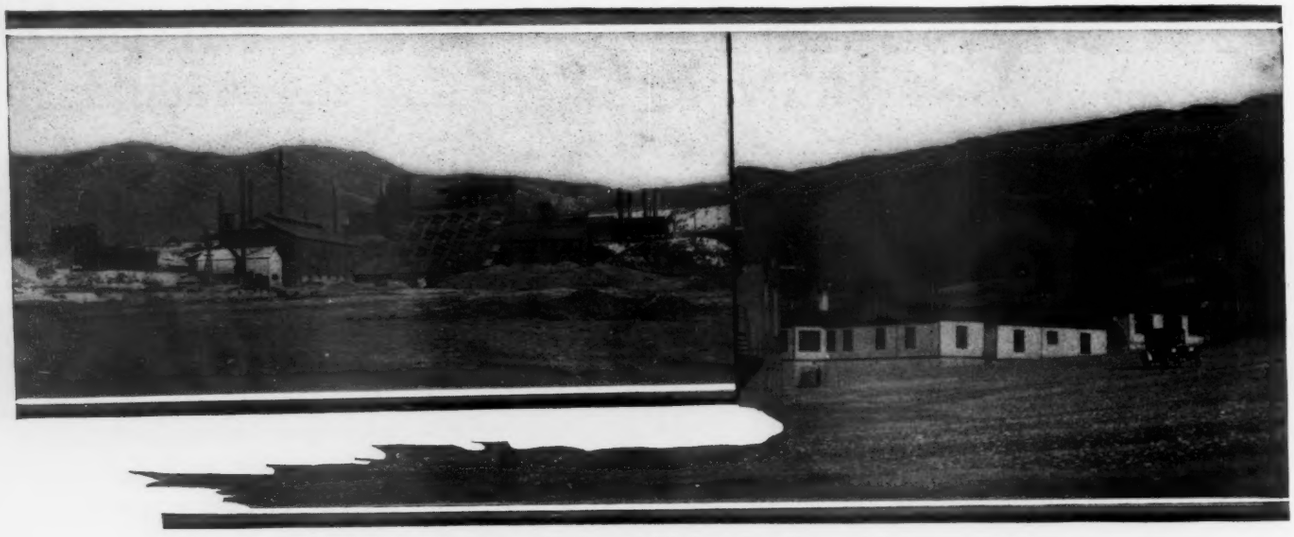
Now in lead smelting, zinc was for years a penalizing factor. That is, the presence of zinc in an ore greatly increased the cost of recovering the lead; and the zinc, then being irrecoverable, was lost in the slag. That state of affairs not only deprived the shipper of lead-zinc ores of large revenues that ordinarily should have accrued to him as the producer of a valuable metal but likewise cut large slices from his receipts in the form of penalties because of the zinc content. A ban was placed on lead-zinc ores; vast tonnages could not be mined; and large mines lay idle, while scores of others faced a shutdown. To comprehend the gravity of the situation, one need only know that, three years ago, metallurgical plants in Salt Lake Valley, Utah, poured on their slag dumps daily approximately 100,000 pounds of zinc valued at about $6,000, or $2,000,000 worth annually. Today, the greater part of this metal is saved, with the result that from Utah ores alone the output of zinc in the Beehive State increased from 8,157,739 pounds in 1920 to 16,000,000 pounds in 1924,



Left—This grinding department, in the plant of the Inspiration Consolidated Copper Company, has a daily capacity of 18,000 tons.

Right—Flotation department in the Hayden Mill at the Ray Mines in Arizona.

Bottom—MacIntosh cells in action in the flotation plant of the Utah Apex Mill at Bingham, Utah.



Left—Mill at Bauer, Utah, of the Combined Metals Reduction Company.
Right—New flotation plant of the Nevada Consolidated Copper Company near Ely, Nev.

and from 52,611,732 pounds in 1925 to 100,000,000 pounds during 1926.

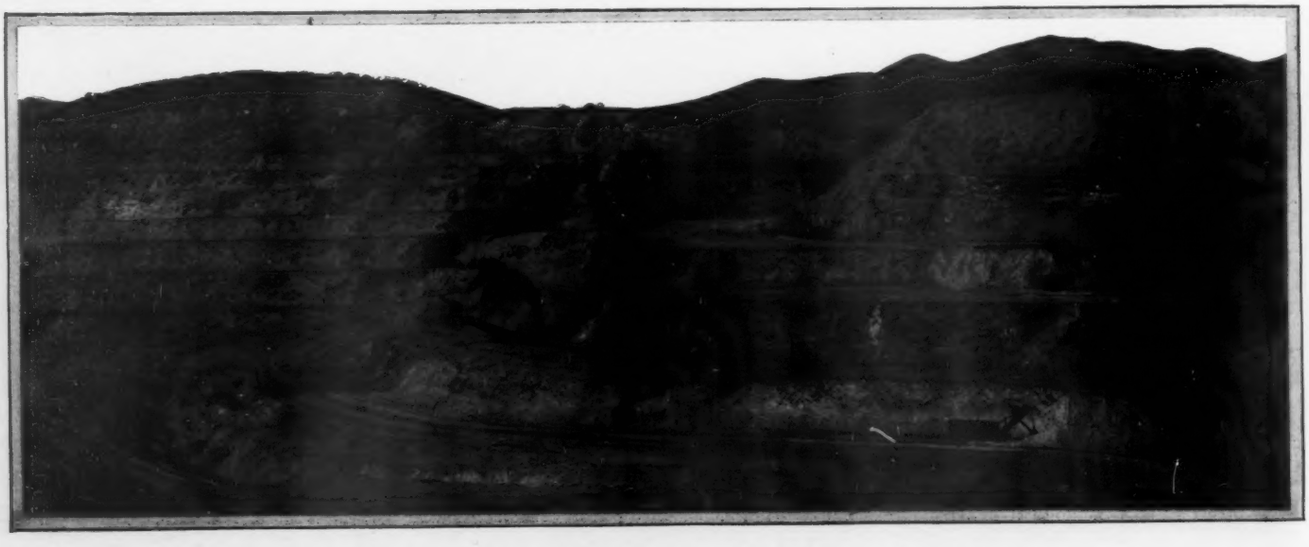
How was this miracle of industrial revolution wrought? By applying to the treatment of ore the elemental principle of surface tension. Nearly everyone has performed the experiment of filling a glass of water until the surface of the liquid stands higher than the sides of the vessel; or of greasing a needle and placing it on water where it will float. In a similar manner, it was found that sulphide-ore particles, when oiled, have a tendency to attach themselves to air bubbles and to float, while the oxide particles—such as quartz, feldspar, limestone, hematite and other gangue minerals, which have less affinity for oil and are therefore easily wetted—sink to the bottom or remain in suspension. Here one meets the first paradox—the heavier particles float while the lighter ones sink. In fact, some of the heaviest sulphide minerals are easiest to float, provided of course they are ground fine enough so that the weight of the mineral particles will not counteract the weight of the bubble.

Flotation, like many other innovations, had a modest beginning and a comparatively slow development. While no one knows just where the idea originated, the first patent on record outlining a procedure that bears a resemblance to present-day practices was taken out by William Haynes in 1860. By this process, the inventor attempted to remove mineral sulphides from oxides by having them adhere to a gummy or a viscous substance, thus proving that he recognized the tendency of sulphides to mix with oils more readily than do oxides or gangue particles.

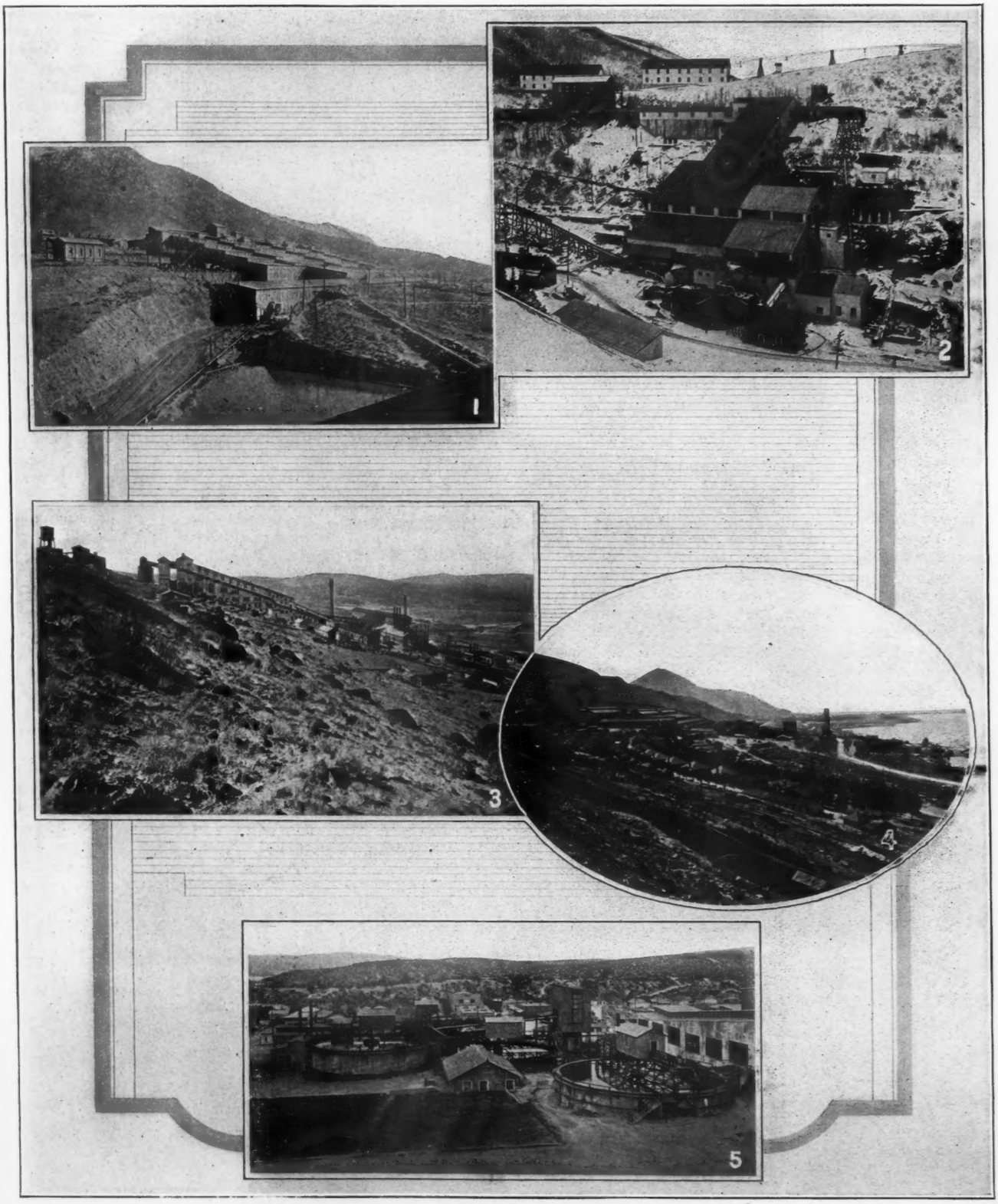
An article on flotation would be no article at all unless it mentioned Mrs. Carrie Everson. This woman—in a story broadcasted by an ambitious but none-too-accurate newspaper scribe and swallowed whole by a gullible and romance-loving public—was painted as a hard-working Cripple Creek washerwoman who beat scientists to fame and fortune by discovering, while washing a miner's ore-plastered overalls, that the froth made by soapsuds and rubbing would float mineral sulphides and that valuable recoveries could thus be effected.

Mrs. Everson was not a washerwoman. She was the wife of Dr. W. K. Everson, and had acquired a considerable knowledge of mining and chemistry. Through her husband's mining investments, Mrs. Everson became interested in mineralogy, and patented the Everson flotation process. Although nothing of practical benefit resulted from her enterprise, Mrs. Everson did discover that the addition of a small quantity of acid to the pulp or crushed ore increased the selective action of the oil in the case of sulphides, and that agitation further aided the separation of the desirable mineral particles from the oxides and waste matter—principles that are basic factors in present-day technique.

Various other inventors contributed liberally to flotation; but the first long stride



Steam Shovel Mine of the Nevada Consolidated Copper Company.



1—Concentrator of the Nevada Consolidated Copper Company.

2—Flotation plant, at Woodside Gulch, Utah, of the Silver King Coalition Mines Company.

3—Timber Butte Mill near Butte, Mont.

4—Arthur Plant of the Utah Copper Company, near Salt Lake City, Utah.

5—Settling tanks at the Hayden Mill, Ray, Ariz.

towards the practical application of this method of ore dressing was made in 1904, when Francis E. Ellmore patented a process for the raising of mineral particles to the surface of froth by the addition of a small quantity of oil and the liberation of air in the pulp. And to Francis Ellmore belongs the distinction of having invented the first workable flotation process; although to Potter, Delprat, and Froment must go the credit for the discovery that oil particles can be raised by air or gas bubbles adhering to mineral sulphides. These pioneers paved the way that led to the recognition of the fact that the key to flotation was neither the oil nor the apparatus but, instead, the air bubbles.

Forrester flotation cells in the plant of the Nevada Consolidated Copper Company.

After the recognition of this principle, the evolution of selective flotation was rapid; and, today, this method of ore dressing is declared to be the foremost metallurgical discovery of the age. According to a bulletin on *The Trend of Flotation,* by Arthur J. Weinig and Irving A. Palmer of the Colorado School of Mines, "No other method of ore treatment has ever effected such great changes in so short a time. This is indicated by the number and importance of the companies now using the process, the tonnage and variety of ores handled, the grade of concentrates produced, and the high recoveries of the metals contained in the ores."

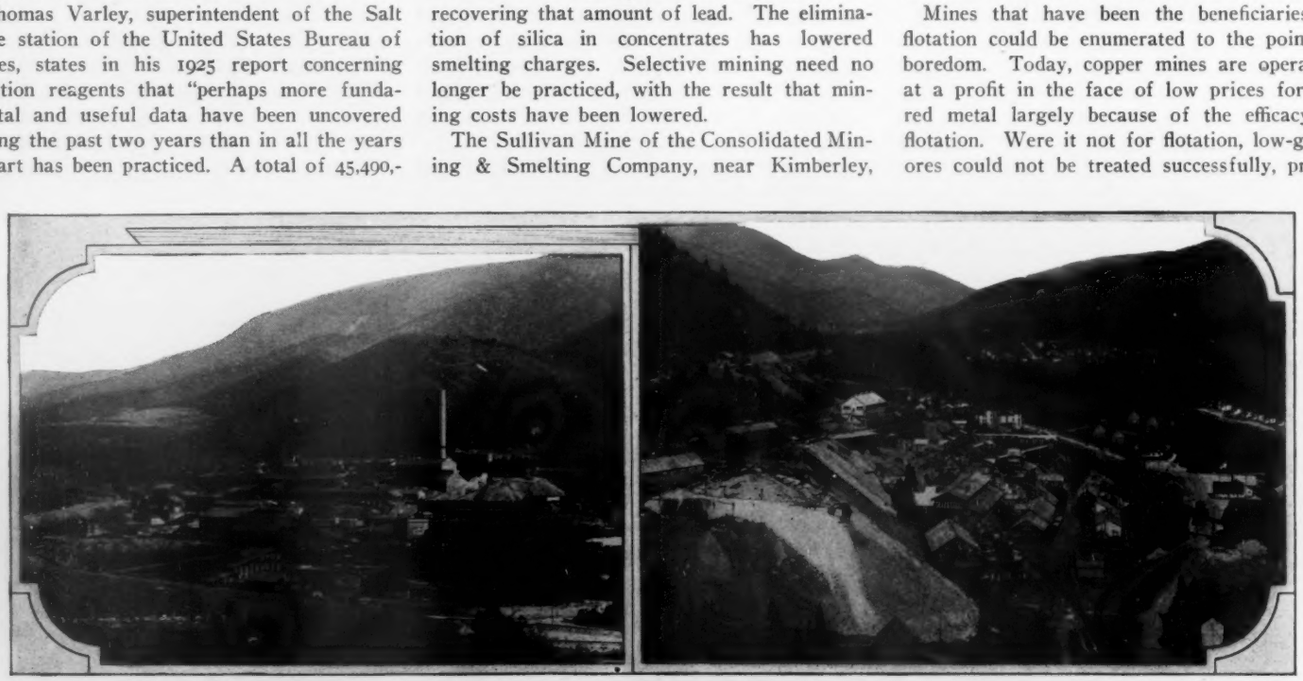
Thomas Varley, superintendent of the Salt Lake station of the United States Bureau of Mines, states in his 1925 report concerning flotation reagents that "perhaps more fundamental and useful data have been uncovered during the past two years than in all the years the art has been practiced. A total of 45,490,331 tons of ore were milled by flotation and 2,790,526 tons of concentrates produced through the use of 81,166,967 pounds of reagents."

To reinforce these statements, a few concrete instances of the great boon conferred by flotation upon mining will be cited: Utah, the second largest lead producer in the United States, yielded during 1926 in round numbers 300,000,000 pounds of the gray metal. More than half of this came from ores which, if treated in a lead furnace by the old methods of pyrometallurgy, would not have covered treatment costs because of the penalties entailed on account of their zinc content. In addition, from 90,000,000 to 100,000,000 pounds of zinc would have been burned up in that twelvemonth in recovering that amount of lead. The elimination of silica in concentrates has lowered smelting charges. Selective mining need no longer be practiced, with the result that mining costs have been lowered.

The Sullivan Mine of the Consolidated Mining & Smelting Company, near Kimberley, British Columbia, affords a striking example of how worthless deposits have been converted into vast bonanzas by flotation. About a decade or more ago, this property was purchased for $250,000 by the Consolidated Mining & Smelting Company. At the time, this seemed a large price for a mine, the ores of which were banned because of the complexity of the zinc-lead-silver association. Years passed, thousands of dollars were spent, still the problem defied solution. Finally, a method of treating the ore was developed; and during 1925 alone the net earnings of this company, before writing off the income tax, were $13,255,406. Of ore carrying about 11 per cent. lead and 7.5 per cent. zinc, the company is said to have sufficient reserves to supply its mill with 4,000 tons daily for many years to come.

The Combined Metals Mine at Pioche, Nev., controlled by the National Lead Company, lay unproductive for years. Today from 150 to 200 tons daily are being shipped from there to the Combined Metals flotation plant at Bauer, Utah. An ore body, measuring over 900 feet long on its dip, 110 feet wide, and 15 feet thick, and carrying per ton an average of 60 cents in gold, 7.8 ounces of silver, 6.8 per cent. lead, and 15.4 per cent. zinc, would be valueless without selective flotation.

Mines that have been the beneficiaries of flotation could be enumerated to the point of boredom. Today, copper mines are operating at a profit in the face of low prices for the red metal largely because of the efficacy of flotation. Were it not for flotation, low-grade ores could not be treated successfully, profits



Left—Bunker Hill and Sullivan Smelter at Bradley, Idaho.
Right—Mill of the Federal Mining & Smelting Company, near Mullen, Idaho.

would be wiped out or reduced to a pitiable figure, and a great industry would be rendered helpless.

Important as is the function of reagents for the purpose of lowering surface tension and forming a stable froth, the contributive part played by compressed air should not be minimized. It is compressed air and agitation that form the froth which becomes dotted with mineral and bears off the desired particles in the form of a concentrate. After the precious mineral particles have been separated from the waste, the filtering of the concentrate and the dewatering of the product for shipment to the smelter are comparatively simple mechanical processes performed by ingeniously designed apparatus.

Methods of using compressed air in flotation vary. Nearly all mines employ single-stage blowers. All flotation processes specify, as the first step, crushing of the ore in order to liberate the mineral particles from the surrounding gangue rock and to reduce them to sufficient fineness so that the weight of the particles shall not burst the bubbles. Following crushing, the pulp is mixed with the reagent and then conveyed to the flotation cell. In the Callow machine, the air is introduced through four thicknesses of loosely woven canvas twill by a blower. The resultant froth is discharged over the longitudinal edge of the tank, while the tailings or waste matter is disposed of by way of a spigot at the lower end of the tank.

Clogging of the porous mat at the bottom of the Callow cell, which causes higher power consumption and increased cost, has led to the development of the MacIntosh machine, also made by the General Engineering Company. In this cell, the fixed mat is replaced by a canvas-covered horizontal cylinder that slowly rotates in the bottom of the cell. Air enters the cylinder through a hollow shaft and then passes outward into the pulp through the canvas covering.

Even more ingenious is the Forrester machine, the most recent innovation, which goes a step further and dispenses with the mat. The air is distributed through the pulp without the use of any porous medium, with a consequent great saving in power, blankets, and labor.

The accomplishments of selective flotation are positively uncanny. Even in vast mills like that of the Utah Copper, at Magna and Arthur, Utah, with a combined capacity of from 45,000 to 50,000 tons daily, a saving of copper ranging from 90 to 95 per cent. is made in the case of ore carrying but 1.1 per cent. copper or 22 pounds of the red metal to the ton, as compared with recoveries averaging around 60 per cent. when milling was first started by the company hardly 15 years ago.

Through the use of reagents, metals can be summoned or repelled almost at will. For example, if it be desired to recover the galena content of an ore, the pulp is introduced into an alkaline circuit, where the silver-lead metal is enlivened and floated off on the froth and the sphalerite or zinc and pyrite or iron are largely inhibited or depressed. However, by conveying the tailings or rejects from the lead cell to a zinc cell, and by subjecting the pulp to the action of copper sulphate, the corrosive or inhibiting agent is removed and the zinc particles are floated off in the form of a concentrate which, after dewatering, can be shipped to the smelter and sold. This, then, is the key to the technique of modern ore dressing—the increase of one mineral's flotative quality by the use of certain flotation agents and the depression of the flotative quality of another until, after successive treatment, the various minerals are segregated into products most desirable for treatment in reduction plants.

Uses of compressed air in milling plants and in mining offer wide contrast. For underground work, air must be supplied on a high-pressure, low-volume basis, but in flotation the condition is reversed and only air of low pressure and high in volume can be utilized. Callow machines require 4 or 5 pounds of air pressure, while the Forrester cells at the Nevada Consolidated Copper Company's plant, near Ely, Nev., operate on 2 to 2½ pounds of pressure.

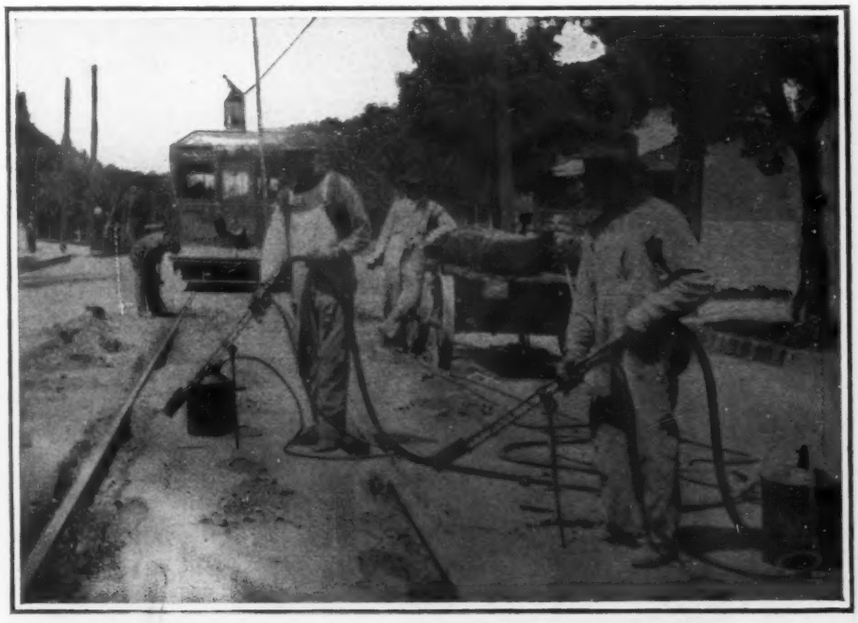
The two compressors recently installed at the Nevada Consolidated are probably the largest low-pressure machines ever manufactured. Each consists of a 1,250-H.P. synchronous motor driving a centrifugal blower rated at 60,000 cubic feet per minute, the air having a pressure equivalent to 3.4 pounds at sea level. At the plant altitude, air will be delivered at 2.5 pounds pressure, Motors, which are directly connected and built into the blower, forming a complete self-contained unit, will operate at 3,600 revolutions per minute. The blowers are of the single-stage type, occupying but 11½x9 feet of space per unit. Power is furnished by General Electric turbine generators.

PREHEATERS USEFUL IN TRACK MAINTENANCE

A change in weather is sometimes troublesome where outdoor work is concerned, as was experienced by the maintenance department in Fort Worth, Tex., of the Northern Texas Traction Company. Last winter, this company found it necessary to repair the paving along certain of their tracks. The day was fine when the old asphalt was torn out; but when it came time to spread a new layer, the weather turned cold and rainy. Under those conditions, the fluid asphalt and the hard, wet subsurface could not be counted upon to unite and to form a homogeneous mass.

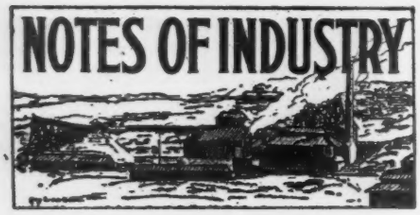
As a result of this difficulty, a kerosene-burning preheater was conceived and constructed in the local shops of the Northern Texas Traction Company. This preheater, as shown in the accompanying illustration, consists of a 2x6-inch burner tube; of a ⅜-inch air pipe, with a cut-off valve, that connects the burner by a suitable length of hose to an air compressor; and of a ⅜-inch fuel pipe to which is attached a flexible hose that taps the kerosene container.

Each preheater is also provided with a staff or leg on which the operator can rest the burner when in use. This simple arrangement makes it possible for the workman to handle the preheater with ease and to keep the flame directed toward one spot as long as necessary without undue fatigue. By the aid of this equipment, the maintenance department is now able to dry out and to heat old asphalt whenever needful so as to induce cohesion between it and new asphalt placed upon it.



Courtesy, Electric Railway Journal.

Air-operated kerosene burners have proved effective in heating asphalt-coated paving preparatory to making street-railway repairs.



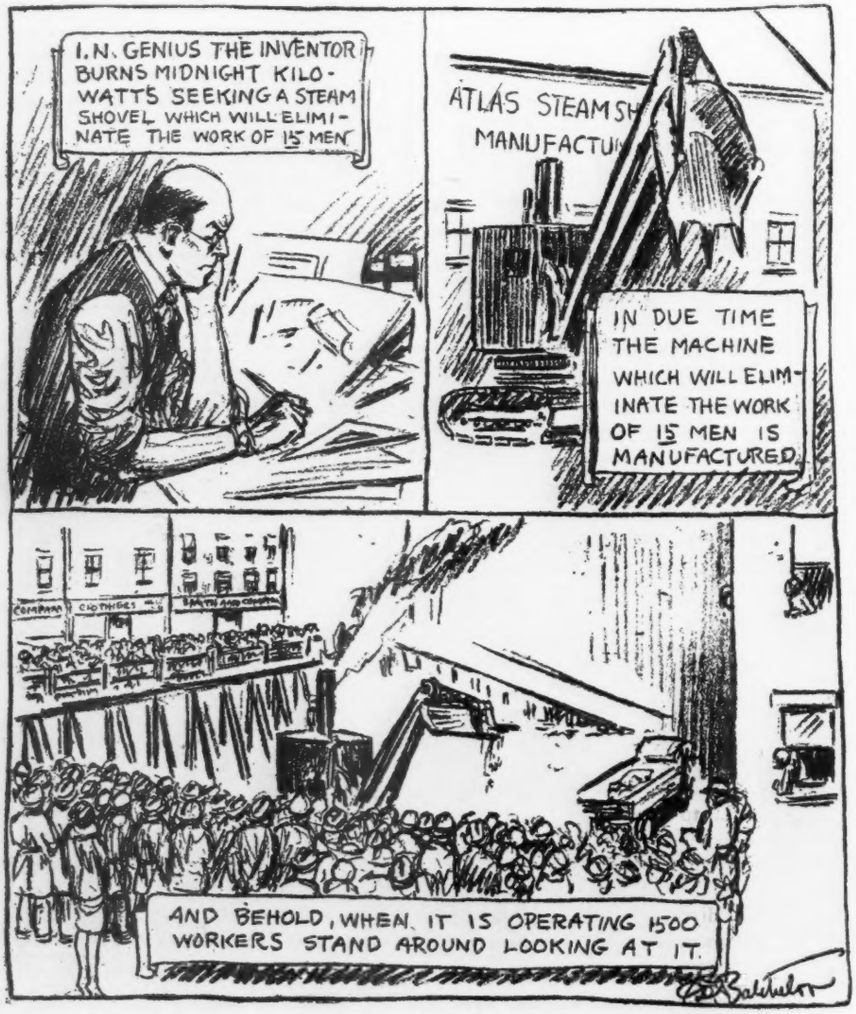
A 5-weeks' course in practical coal mining is offered free of charge to all men working in and about bituminous or anthracite collieries by the School of Mines and Metallurgy of the Pennsylvania State College. The course begins on Monday, June 20, and ends July 23, and is designed to prepare men for the State Department of Mines' examination for fireboss or for mine foreman, or to fit men who have already passed these examinations for higher positions. Anyone desiring to enroll should communicate with E. A. Holbrook, Dean, The School of Mines & Metallurgy, State College, Pa.

Between 1859 and 1924 approximately 661,679 wells were drilled in the United States for oil and gas. Of this total 129,875, or about 20 per cent., were dry holes.

The production of soft iron directly from iron ore has been successfully accomplished at the Forsbacka Works, in Sweden, according to a statement made by an official of the plant. The process—the Flodin-Gustafsson method—is an electrical one by which lumps of iron ore can be converted into pure iron or steel ready for use. Experiments, covering a period of eight months, have proved that the process can be employed for making rustproof iron at a cost not greater than that charged for ordinary iron.

Working in the Research Laboratory of the Westinghouse Lamp Company, J. W. Marden and M. N. Rich have been able to produce vanadium. It is claimed that the metal is not brittle and may be cold worked into wire or other forms.

According to a survey completed by the United States Bureau of Public Roads, the 1926 automobile registration and license fees brought into the state treasuries a total of $288,282,352. Of this sum $190,406,060 was made available for roadbuilding under the various state highway departments, while the counties received $51,702,184 for the improvement of local roads.


I. N. GENIUS THE INVENTOR BURNS MIDNIGHT KILOWATTS SEEKING A STEAM SHOVEL WHICH WILL ELIMINATE THE WORK OF 15 MEN
ATLAS STEAM SH MANUFACTU
IN DUE TIME THE MACHINE WHICH WILL ELIMINATE THE WORK OF 15 MEN IS MANUFACTURED
AND BEHOLD, WHEN IT IS OPERATING 1500 WORKERS STAND AROUND LOOKING AT IT.

Courtesy, Philadelphia Public Ledger.
So this is progress!

Of China's immense population, numbering approximately 400,000,000, at least 80 per cent. is engaged in agriculture.

Important plans were recently approved by the Tees Conservancy Commission that will make Middlesbrough one of the most important ports in Great Britain. Approximately $2,500,000 are to be spent in reclaiming land and in deepening the River Tees as far as Stockton, a distance of 12 miles. It is estimated that it will take from 8 to 10 years to complete the undertaking.

The Mines Bureau of the University of Alberta, in Canada, has been studying the practicability of extracting the bitumen content from tar sands and the possibility of using the material for roadbuilding in and around Edmonton. Extensive deposits of tar sands are known to exist in the vicinity of Fort McMurray, 300 miles north of Edmonton. In this connection it is interesting to note that French roadbuilders have found bitumen to possess numerous advantages over tar in the construction of highways. It has been determined, after months of testing, that it dries quicker, is more adhesive, and wears better than tar.

As a result of the phenomenal development within the past few years of the oil industry in Venezuela, the City of Maracaibo has earned for itself the title of the "Tampico of Venezuela." The town is rapidly being turned into a thoroughly modern seaport that will be capable of handling the steadily increasing shipments of crude oil that pass through that port.

Work has been started on another link in the proposed transcontinental railroad that is to connect Adelaide, on the south coast of Australia, with Darwin, on the north coast. The new line extends from Oodnadatta to Alice Springs—a run of about 291 miles, and will open up a vast section of undeveloped territory.

How good roads and motor transport can bridge the gap between distant points is strikingly brought out in the case of a weekly automobile service established recently between Broken Hill and Abercorn, in northern Rhodesia, a distance of 600 miles. Owing to the prevalence of the tsetse fly in the region, which prohibited the use of draft animals, the only available means of transport were native carriers. These men required 40 days to make the journey that the motor car now completes in 4 days of 150 miles each.

Recent work with andalusit—an aluminum silicate mineral—has proved the material to be of value in the production of heat-resisting refractories. After grinding, the mineral is mixed with an organic binder, shaped into bricks, and then burned in tunnel ovens. It is claimed that these bricks are able to withstand a temperature of 3,092°F. for months running, and are therefore especially serviceable for use in metallurgical furnaces.

Compressed Air Magazine

—*Founded* 1896—

Devoted to the mechanical arts in general, especially to all useful applications of compressed air and to everything pneumatic.

Business and Editorial Offices:

Bowling Green Building, No. 11, Broadway, New York City. Tel. Bowling Green, 8430

Publication Office: Somerville, New Jersey

TERMS OF SUBSCRIPTION

$3 a year, U. S. A., American possessions and Mexico; all other countries $3.50 a year, postage prepaid. Single copies, 35 cents. Back issues more than six months old, 75 cents each.

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EDITORIALS

MISSISSIPPI TAKES TOLL FOR MAN'S INTRUSION

THE Mississippi River, "The Father of Waters," has lately been anything but beneficent in its mood. The spring flood or freshet period has brought down an unusually large volume of water that has spread devastation and even death throughout a wide area. Man's relatively puny efforts to curb and to guide the flow of that mighty stream have been in numerous instances ineffectual; and once more the nation's engineers that have this great problem in their hands must seek a solution that will lessen the hazards and possibly effectually prevent a recurrence of conditions now confronting the dwellers within those areas that have lately suffered most because of the Mississippi on a rampage.

In order to visualize something of the magnitude of the protective task, we have only to recall the outstanding and imposing figures concerned with the Mississippi River. To begin with, from its northernmost source to the Gulf of Mexico, the stream is 2,550 miles long, and its tributaries add thousands of miles to an associate system of waterways that drains an area of approximately 1,250,000 square miles. The run-off from this vast territory, this basin or watershed, has ultimately to find its way seaward through a single channel that, compared with the potential maximum volume of flow, is decidedly constricted in the neighborhood of New Orleans and for a good long distance below that city. In other words, just where that mighty stream is in need of a greatly amplified outlet, the course of the water is bottle-necked; and this condition prevails for nearly 100 miles further southward.

During a period of 200 years, man has progressively striven to reclaim for his own use the fertile delta lands contiguous to the mouth of the Mississippi; and, by the dikes and levees reared for this purpose, lands formerly overflowed by the river during flood periods have been protected from those relieving inundations and generally turned over to the farmer for profitable cultivation. In short, man has figuratively sat upon Nature's own safety valve, hoping that there would never come a time of accumulated pressure that would lead to devastating ruptures. Now, by an irony of Fate, man has been forced for his own security to provide relief against gathering pressure by opening up wide breaches in his defenses at various points so that the Mississippi may make short cuts into the Gulf of Mexico—thus giving back to the river substitutes for the channels it had before the normal passageways of that stream were curtailed by private enterprise and Federal coöperation.

Possibly, engineering skill may devise means by which the flood waters can be held within bounds and a recurrence of the recent disastrous inundations may be prevented; but it is manifest that no permanent solution will be found until provision is made for the maximum possible volume of water that may sweep southward at any time from the enormous watershed drained by the Mississippi and its tributaries. Success in the undertaking would compensate for whatever sums might be needed to carry out a matured and enduring system of protection.

ANOTHER ALPINE TUNNEL IS PROPOSED

THE air-driven rock drill has, prospectively, a task ahead of it in the Alps if the scheme urged by Prof. FILIPPO TAJANI of the Milan Polytechnic be accepted and sufficiently financed. This Italian scientist, after comprehensive geological studies, is satisfied that there are no prohibitive physical conditions that would prevent the driving of his projected tunnel beneath the well-known Stelvio Pass.

The tunnel planned would have a total length of nearly 12 miles and would be the means of linking, by direct line, Genoa and Milan with Munich, Stuttgart, and the very heart of Germany generally. According to news reports, the undertaking would entail an outlay of substantially $1,500,000 a mile. The geological conditions that would, in all likelihood, be encountered would not differ much from those existing where the Simplon Tunnel was driven, except that Professor TAJANI is satisfied that there are no water-bearing strata along the route to occasion the trouble experienced from water when putting the Simplon Tunnel through the Alps. There is every reason to believe, though, that the same high rock temperatures would be met that proved so exhausting to the drill runners when the earlier tunnel was driven. Even so, this need not discourage the promoters, because there are available today means of ventilating underground workings of this character that were nonexistent years ago.

Indeed, the project may prove easier of accomplishment and less costly than has been estimated. Proof of this lies in the splendid work that has been performed latterly in the United States in connection with the Moffat Tunnel and the Cascade Tunnel. In the case of the Cascade Tunnel, especially, modern rock drills in the hands of capable runners have been able to advance a 10x10-foot heading 984 feet in the course of 31 consecutive days—representing the removal of 3,644 cubic yards of rock. The Cascade Tunnel, by the way, will be a little short of 8 miles in length. Surely, Europeans, employing similar equipment for drilling, mucking, and other associate work, should be able to complete the tunnel advocated by Professor TAJANI in the course of about 6 years.

MUCH LONGER POWER LINES A PROBABILITY

IN the field of electrical distribution, the term superpower has latterly been used freely to mark a new era in the economical utilization of current generated at strategic points by master power stations. Feasible as superpower hook-ups have been proved to be in dispatching hither and thither great blocks of energy to take care of peak-load demands at widely scattered points, still the electrical engineer has been generally held within a maximum limit of approximately 200 miles in transmitting current without suffering costly losses. This has meant that natural sources of electrical energy—such as waterfalls and streams with rapidly descending channels—could not be utilized to advantage in developing large blocks of power because possible consumers were too remote for the commercial transmission of the current.

Now, thanks to the research and the inventive cunning of FRANK G. BAUM, it seems likely that we may see a revolutionary change in the long-distance transmission of electricity for power purposes. Heretofore, in transmitting alternating current at high pressure, cumulative reactions have been set up in very long conductors that have induced unstable electrical conditions. These have either seriously affected the efficiency of the line or have actually made it practically inoperative because of abnormal voltages developed at intermediate points between the source of energy and the remote users.

The Westinghouse Electric & Manufacturing Company has acquired MR. BAUM'S patents, and, inferentially, thus endorses the general claims of improvement made by the inventor although it may not yet be convinced that the full measure of his claims is obtainable. Mr. BAUM is said to have declared that it would be feasible to transmit power by wire for distances of fully 1,000 miles—the incident electric losses being so low as to make this a commercial success. If this should prove to be true, the application of the principles and apparatus required would be of tremendous benefit.

As described by Mr. BAUM: "My invention covers the connection of a plurality of automatically regulated synchronous condensers at substantially uniformly spaced points directly to the high-voltage transmission line. The practical effect of such a procedure is

to transform the long line into a series of relatively short lines, in each of which the factors that cause instability can readily be controlled."

Even a partway attainment of the inventor's expectations will prove of enormous help not only to every industrial phase of our national life but to those other and even more numerous consumers who use electric current in their homes. We hope that MR. BAUM'S fullest claims may ultimately be realized.

FROM AFRICA TO VENUS

MANY amazing things have developed of an archeological nature in Africa, and now we are told that that most backward of all the continents was possibly the source of the human race! Some of us may react skeptically to this recent pronouncement of certain scientists, but we have to admit that their guessing may be closer to the fact than our doubting.

According to the Director of the Logan African Expedition of Beloit College, Wisconsin, there were found within the present year on the site of an ancient camp in Algeria the skull and numerous bones of the skeleton of a child that probably died 60,000 years B. C. If the anthropologists concerned be right in their assumption regarding the age of those bones, they may yet be able to convince their confrères and the world at large that man did have his birthplace on this earth in Africa and not in the Gobi Desert or elsewhere as has been advanced before.

We of the present age and generation need not be especially perturbed about where our remote forbears started their physical existence in the dim past, because, happily for the human race, the vast majority of us give every indication of having moved a long way forward during the interval. However, there is occasional evidence that some of our fellow beings may be intellectual throwbacks to the time of our origin, recalling as we easily can that Africa has been known for a goodly while as the Dark Continent.

But whether or not the human race started there, many millions of people are more interested in what is going to happen to us in the course of time. In this direction, B. S. HALDANE, a Cambridge scientist, has lately proclaimed in the *London Graphic* that only 10,000,000 years hence our descendants are to be shot *en masse* to Venus where they will thereafter take up their abode for an indefinite period. Whether or not other and existing inhabitants of that shining planet will object to such a wholesale influx and rear legislative bars against further immigration of a kindred sort is not discussed; but we may reasonably assume that the change of habitat will prove a long step forward in the march of human betterment. This should be glad tidings to those persons that worry so much about the future of the race.

ANNOUNCEMENT

The executive offices of the Canadian Ingersoll-Rand Company, Ltd., are now located at 10 Phillips Square, Montreal, Que., Canada.

HOW TO WIN AN ARGUMENT, by Profs. Richard C. Borden and Alvin C. Busse. A work of 166 pages, published by Harper & Brothers, New York City. Price, $2.00.

IN the last analysis, the winning of an argument lies in presenting the facts supporting one's side of the question so persuasively that the other side accepts them and acknowledges their force. Persuasiveness does not mean volubility—it does not mean tiring out the opposition so that assent is given merely to obtain quiet or to get the matter disposed of at all odds. Persuasiveness in argument involves that nice consideration of the other fellow's viewpoint—giving him a chance to say his say, and then refuting him with a decent regard for his feelings.

The authors have dealt with their subject in a purposely elementary way so that the reader could grasp readily the fundamental principles underlying a well-rounded argument. They very rightly believe that the knowledge offered by the book will be a help in the business conference room and among salesmen when meeting opposition.

THE IDEALS AND FOLLIES OF BUSINESS, by William Feather. A book of 199 pages, published by The William Feather Company, Cleveland, Ohio.

THE author has entertained and inspired by his jocular treatment of his subjects the practical-minded man who so often misses the encouraging aid of a little humor. In his present book, Mr. Feather has pursued his own delightful way in having his playful jab at business and its ideals and follies. Most of us might read with profit what he has to say, and, incidentally, find life and our daily work brighter and easier if we could see things now and then as he does. One besetting trouble that most of us have to contend with is that we take ourselves and our problems too seriously, and we are apt to think that our way of doing things is necessarily the best if not the only way. As he tersely puts it: "We can keep young as long as a new idea doesn't hurt us." A lot of us are older than our years because of a chronic attitude of opposition to all new suggestion.

DIESEL ENGINES, by Arthur H. Goldingham. A copiously illustrated work of 255 pages, published by Spon & Chamberlain, New York City. Price, $7.50.

THIS excellent work, which has been a source of guidance since it first appeared, has been brought up to date in the present third edition. In the interval, notable progress has been made in the design and the construction of both marine and stationary Diesel engines—especially in those engines intended for service afloat. Therefore, in order to cover the advance, it has been necessary to revise drastically and to rewrite much of the original text. The third edition should prove valuable to the student, the draftsman, the consulting engineer, the owner, and the prospective purchaser of a Diesel engine for use either ashore or afloat. As he tells us in his preface: "The comprehensive character of this work is largely due to, and has only been made possible by, the coöperation of the numerous manufacturers who have so readily furnished data pertaining to their respective designs, and is enhanced by the magnificent collection of sectional views and other illustrations of both marine and stationary types which they have placed at the author's disposal."

Gas-Measuring Instruments is the title of Circular 309 issued by the United States Bureau of Standards. This publication can be obtained for forty cents a copy from the Government Printing Office, Washington, D. C.

Economy is the title of a booklet issued by Greene, Tweed & Company, 109 Duane Street, New York City. This publication should appeal to anyone interested in the manufacture and sale of rod packings. It can be had free upon request.

Developing Machinery Markets Abroad is the title of a pamphlet issued by the Bureau of Foreign & Domestic Commerce of the United States Bureau of Commerce. The pamphlet contains much valuable information and many helpful suggestions.

The Industrial Hose Handbook is the title of a brochure issued by the Electric Hose & Rubber Company, Wilmington, Del. The pamphlet contains much useful information and can be had free upon request.

The following new publications of the United States Bureau of Mines can be bought from the Superintendent of Documents, Government Printing Office, Washington, D. C.:

BULLETIN 240. Electric Shot-Firing in Mines, Quarries, and Tunnels, by L. C. Ilsley and A. B. Hooker. 139 pp., 72 figs., 35 cents.

BULLETIN 249. Manual of Testing Methods for Oil Shale and Shale Oil, by L. C. Karrick. 70 pp., 24 figs., 20 cents.

BULLETIN 254. Smoke-Abatement Investigation at Salt Lake City, Utah, by Osborn Monnett, G. St. J. Perrott, and H. W. Clark. 98 pp., 24 figs., 30 cents.

TECHNICAL PAPER 370. The Bowie-Gavin Process, its Application to the Cracking of Tars and Heavy Oils, Also to the Recovery of Oil from Oil-Soaked Sands or Shales, or from Oil Shales, by C. P. Bowie. 42 pp., 14 figs., 15 cents.

TECHNICAL PAPER 394. Dust Respirators, Their Construction and Filtering Efficiency, by S. H. Katz, G. W. Smith, and E. G. Meiter. 52 pp., 28 figs., 15 cents.

TECHNICAL PAPER 402. Safety Rules for Installing and Using Electrical Equipment in Coal Mines, Sponsored by U. S. Bureau of Mines and American Mining Congress. 21 pp., 5 cents.